Every government degenerates when trusted to the rulers of the people alone. The People themselves are the only safe depositories. And to render even them safe their minds must be improved . . . I think by far the most important bill in our own code is that for the diffusion of knowledge among the people . . . No other sure foundation can be devised for the preservation of freedom and happiness.—THOMAS JEFFERSON

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SHORT TERM AND LONG TERM EFFECTS OF THE WAR ON THE SECONDARY CURRICULUM IN MATHEMATICS

WILLIAM L. HART
University of Minnesota, Minneapolis, Minn.

Ever since our present national emergency arose, it has been evident that the whole field of education has the double duty of adjusting itself quickly to the needs of the moment and, at the same time, of planning for the post war period. During the last few weeks, on account of the lowering of the minimum draft age to eighteen years, an analysis of the immediate effects of the war on secondary education in general, and particularly on secondary mathematics, has become increasingly important. Before this, some of the most desirable war time actions in regard to high school mathematics were undoubtedly being delayed or omitted in many localities because of the notion that whatever was not done in the secondary schools could, if necessary, be accomplished later in the colleges. The same idea, in peace time education, has long been a retarding influence in connection with the development of a coherent program for secondary mathematics. In saying this, I am recalling to you that, before the war, some people believed that a great deal of the substantial part of secondary mathematics was useful only for later college purposes and that, by itself, this mathematics had only very limited objectives. In opposition to such a viewpoint, I have always taken the position that, if the high schools should develop *any* mathematical program which gives maximum opportunity to the intelligent students for learning mathematics and its applications, the college mathematical cur-

riculum could easily be adjusted to the final high school level. In fact, I have been hopeful that a rational approach to substantial secondary mathematics based on the idea that it, as a field, has valuable terminal objectives, would *raise* the entering level of mathematical knowledge among college freshmen.

The preceding attitude is so important both during the emergency and in planning for the post war period that I shall use the announced viewpoint as a unifying principle in most of my discussion today. Thus, I shall assume that, not only during the emergency but, also, after the war, the field of secondary mathematics should aim at definite objectives independent of later college contacts. And, I repeat, it is my opinion that such objectives would in the large be consistent with the aims of collegiate mathematical fields.

In order to develop a background for later explicit curricular suggestions, let us consider certain pedagogical viewpoints and also, some mathematical features of the war time situation which should affect our conclusions.

First, it is proper to take notice of complaints which have arisen in industry and the armed forces concerning the mathematical proficiency of the men and women whom we have trained in our high schools and colleges. A mathematical weakness of our former students which has been strongly emphasized is their lack of ability to carry out successfully and quickly the fundamental operations of arithmetic and the most elementary algebra. Unquestionably, a considerable lack of such ability exists *unnecessarily*, due to the fact that, in the last twenty five years, many students of satisfactory types have not been encouraged or required to study as much mathematics as the nation should demand in the case of intelligent citizens. However, I do not subscribe to the opinion that the preceding cause accounts for all of the mathematical weakness which exists. Our methods of teaching the content of our courses, and the chronological order of the high school courses in mathematics and other subjects probably are responsible for some of the lack of mathematical skill on the part of adults in our population. Some of my later curricular suggestions are designed to remedy defects of this nature.

Aside from the causes of admitted mathematical deficiencies in the past training of men entering the armed forces and industry, it is interesting to question the *extent* of the existing mathematical weakness. It is my opinion that the mathematical

ability of some of these men is *not* as low as certain critics claim. I take this position because I know that some of the criticisms have been based on examinations given suddenly, without the opportunity for review, to men who have not been in school or have not used mathematics appreciably for many years. It is not proper for anyone to decide that a man is at a low level, mathematically, when the diagnosis is not preceded by proper review. All critics of the mathematical products of the schools must remember that mathematical skills are very easily forgotten when not in use. Also, such critics should note that mathematical knowledge can be very quickly refurbished and improved as compared to its former condition.

Failure to recognize the preceding facts may be considered the main cause for certain fallacious remarks, not connected with the war, which in the past have been made about the mathematical abilities of many graduates of high schools and colleges. Some of these remarks have come from the business world and others have arisen in the field of education. In fact, the age old habit of each teacher of mathematics declaiming against the lack of success of the teachers at lower levels is due intrinsically to the psychological feature which I am emphasizing at this moment. For instance, entering college students in some instances have been mis-labeled as poorly prepared because of their failure on placement tests, given without review, whereas the men were only rusty in the mathematical sense.

At one time, at the University of Minnesota, my department carried out an experiment with hundreds of entering freshmen to prove the point of my present remarks. We gave to these students a standard diagnostic test on the *first* day of their first college course in mathematics, without review. Then, we disregarded the test scores and kept all of the students in the course. Later, at the end of two weeks of regular work, we gave an examination which definitely overlapped the material on the placement test. At the end of the term we determined the correlation between final course grades and the scores on the placement test and also between course grades and scores on the test given at the end of two weeks. Due, I believe, to the effects of variable rustiness among the students, the test given on the first day was practically worthless as an indication of eventual performance in the course. The results on the test given at the end of two weeks correlated to an astonishing extent with the final course grades. I mention this statistical investigation in

order to help bury the old bone of contention about the *badness* of instruction *below* the level of any given course in mathematics. Also, I call attention to the clear evidence here that the effects of *rust* on mathematical knowledge probably vary greatly among individuals in spite of their more uniform abilities to attain mathematical skill if it is constantly in use. In the implied defense of the previous elementary mathematical training of men now entering the armed forces, I do not wish to be interpreted as denying that *something drastic must be done* to raise the level of their mathematical skill *at the time of entrance* into the Army or Navy. A later curricular suggestion will bear on this feature.

A second valid criticism of our past mathematical instruction, which is coming to us from the front lines of war time education in the armed forces and industry, is that our former students, who may have learned various mathematical skills, apparently have not accumulated enough power in the use of these skills in applications outside the field of pure mathematics. In other words, it appears that we have not been giving our students enough experience as *applied mathematicians*, and this could be said with as much force about most of the students from college classes as about men or women whose training stopped at the high school level. This lack of the power to *apply* mathematics is a fundamental weakness for which, I believe, all of us must shoulder some of the blame. In talking here of the applications of mathematics, of course I am referring to applications in a very general sense, meaning not only the use of mathematical skills to obtain mathematical results, but, also, the use of mathematics, perhaps theoretically, *in order to understand other important fields* of knowledge. We must recognize that the power to apply mathematics successfully cannot be gained by *review* if the power never existed before. Hence, in the schools of the armed forces, many of the students now are being given an entirely fresh mathematical experience, and not a mere review, when they receive training in the application of mathematics.

As teachers of mathematics, we must seriously take to heart this error about applications in our previous instruction. Hereafter, we should always have in mind the definite objective of *teaching the students to apply mathematics*. This aim will not be easily attained because, as all of us know, it is much easier for a student to solve twenty *given* equations than *to set up one equa-*

tion for an applied problem. The aim places a distinct responsibility on those who prepare the text materials for the courses and, also, on the teachers. First, possible fields of application must be canvassed thoroughly for appropriate material. In the high schools, subject matter fields in which there exists the possibility for mathematical applications *should definitely cease catering to those students who cannot or will not learn mathematics; these associated mathematical fields, such as physics and chemistry, should use mathematics to the greatest possible extent.* The objective of encouraging applications also places on the teachers of mathematics the responsibility for obtaining enough knowledge of fields of application so as to present related problems in a live fashion. I wish to emphasize, however, that all the applications in our courses need not be real and in fact cannot be real. As many of them as possible should be definitely *real*, in the sense that the methods of solution are the ones actually met in the related field. However, others may only *sound real* or may be *pseudo real* in the sense that they deal with real situations but are solved in our courses by methods not employed in the related field. Such unreal or pseudo real applications definitely can be defended. For, one of our main efforts in teaching applications is to instill the idea that mathematics *can* be applied successfully and to teach the general "tricks" of performing applications; even unreal problems are useful for this purpose.

I hope that all of us are aware of the dangers faced in connection with *unintelligent* emphasis on applications. Particularly any *so-called* course in mathematics, which elevates nonmathematical items to such a primary position that the mathematical thread is concealed, thereby loses its identity and justification as a part of mathematics. Such a course would lack the requisite amount of mathematical content; also, the *generality* of this content would probably be concealed from the students. A danger of this nature is met in some of the socialized courses in mathematics and, more recently, in attempts to teach mathematics through aeronautics rather than aeronautics through mathematics.

Another danger connected with the aim at applications is that some people may forget the importance of those applications where we use mathematics as a *language* for understanding other fields rather than for actually obtaining *results* in these fields. Such forgetfulness would lead some people to think that there

no longer is a necessity for emphasizing the basic *ideas* as contrasted with the mere *skills* of mathematics. Frequently it is these basic *ideas* and *methods of proof* which become important in the use of mathematics as a means for attaining an understanding of content in other fields.

Next, I wish to emphasize the obvious truth that individual differences must be recognized among students and that our courses must be adjusted accordingly. This notion is bound up with the idea that the only decent way to teach mathematics is to carry the instruction to the point of *mastery*. Any other type of instruction carries in its wake a heritage of dislike for mathematics on the part of the students and, in any case, is indefensible educationally because nothing is actually *taught* until it has been learned to the point of *mastery*. Hence, we must be particularly careful now and after the war in connection with the placement of students in mathematical courses. We must not locate them over their heads in mathematics which they cannot learn to appreciate.

In order to assist in this teaching for mastery, I recommend that we cease trying to placate students *who will not work consistently and regularly* in mathematical courses. We must come out frankly and firmly, in contacts with administrators and parents, with the opinion that mathematical instruction cannot be carried on successfully without regular student effort. As a means to insure such regular effort, I recommend trying to place mathematics on a *laboratory* basis in the high schools. In this suggestion, I am inferrring that *two* hours would be assigned to replace any *single* hour as the courses are now being taught. If the work were to be given in this way, then instruction could be followed by sufficient *required and supervised study* so that the student would be protected from his human tendencies to informal or irregular study. I strongly urge you to try such a system on a large scale in your schools during the present emergency period.

As another underlying viewpoint, I wish to emphasize the importance of *overlearning* in connection with mathematics. In making this statement, I imply that the average individual is unable to work efficiently in the applications of mathematics if he has just the bare *minimum* of associated mathematical background. Thus, a man cannot be expected to *use* elementary algebra well, if that is the limit of his training; I do not believe that an engineer can be expected to use *elementary* calculus *efficiently*

unless he has studied *advanced* calculus. To the credit of the Army and Navy, it can be said that they appreciate the point which I am making. Of course, each of the armed forces must take short cuts in war instruction because of the preciousness of *time*. But, various Army and Navy spokesmen have explicitly asked help from the schools so that *fewer* short cuts will be necessary in the training programs of the armed services. It is likely that the failure of the high schools to encourage students to overlearn fundamental elementary mathematics by taking more advanced courses is one of the principal reasons why the elementary parts of the subject have been applied so poorly by many men in the armed forces.

After this presentation of fundamental viewpoints, let me offer a program for secondary mathematics during the war period. For brevity, I shall now present my remarks dogmatically in outline form. In some of my statements, I shall be briefing certain parts of my preliminary discussion. I cannot claim any great originality for most of my suggestions.

1. *Should a single, connected sequence of war courses in mathematics and its applications be provided?* Briefly, the answer to this question is "NO." It is more essential than ever before that each high school should adopt all possible measures to adjust the mathematical curriculum to individual differences.

2. *Major war objectives of secondary school mathematics.*

(*a*) For efficiency in civilian life and in the armed forces, each student who graduates from a high school should emerge with his or her basic elementary mathematical skills at a maximum level. A reasonable requirement concerning such knowledge might well be inserted as a hurdle to be surmounted prior to graduation. To accomplish this aim, a student in the last semester of grade twelve should be offered a review of arithmetic, intuitional geometry, and very elementary algebra for two or three hours per week if he is unable to pass a suitable preliminary test covering this material.

(*b*) As many students as possible should study and pass courses in mathematics through advanced algebra and plane trigonometry. This action is desirable because (*i*) many women will be needed to handle mathematical features of industry and to enter professions where mathematics is employed; (*ii*) the Army and Navy need practically unlimited numbers of young men with this training and, moreover, *they may have no opportunity to receive it in a college;* (*iii*) such training is basic for

the men and women who will be encouraged to commence collegiate work in essential professional fields.

(*c*) A larger ***super-select*** group than usual should study mathematics for four years in high school. These students may be needed, ***without time for college training***, to fill some of the most important places in the air forces of the Army and Navy and in the Merchant Marine. Others, both boys and girls, will be needed to fill the reservoir of collegiate candidates for the many essential technical professions.

3. *The role of secondary mathematics in the war program of accelerated education.* For many types of professional collegiate training, a substantial part of a college year may be cut from the normal time for the work if a student has had the maximum amount of secondary mathematics, supplemented by credits in sciences and modern languages. The high schools should canvass every means to accelerate students in their mathematical programs, for instance, by permitting the taking of two courses at once. To avoid the confusion, loss of time, and probable deficiencies which would be associated with new ***streamlined courses*** especially created for the present emergency, the preceding policy of ***doubling up on standard courses*** is recommended instead. This method is suggested particularly for the best students, who then might be able to enter college after only three years or less of high school work. If these students should remain in high school after finishing the usual four year sequence in shorter time, they should then be given individual instruction in the beginning college courses in mathematics.

4. *Items concerning the explicit details of a curricular plan.*

(*a*). The students in grade nine should be classified ***as to mathematical ability***, for instance, into a lower Group I and a superior Group II, ***regardless*** of their present vocational desires, collegiate intentions, and economic circumstances.

(*b*) In grade nine, Group I should study a course made up largely of arithmetic, with only the simplest algebra and intuitional geometry included. In place of exclusive emphasis on ***consumer*** types of arithmetic, shop arithmetic and algebra also should be featured for both boys and girls. In grade ten, the most successful students of Group I should commence the courses to be started in grade nine by Group II. In grade ten, the less successful part of Group I should continue with a second course in mathematics including more arithmetic, algebra, and geometry, and a very simple introduction to trigonometry.

(*c*) In grade nine, Group II should commence a four-year co-ordinated sequence in mathematics, physics, chemistry, and their applications. The mathematics in grades nine and ten should involve the usual first year of algebra and a year of geometry, either in sequence or as an integrated two-year program. The year of substantial algebra, studied in classes from which the *poorer* students have been *excluded*, should make it satisfactory to use only *one* semester instead of a whole year for the typical second course in algebra. A small unit of trigonometry and a large unit of *intuitional solid geometry* should be included in the courses for Group II in grades nine and ten. Failures or near failures in Group II should be dropped back early to the simpler course provided for Group I. In grade eleven, as many as possible of Group II should take one semester of advanced algebra followed by a semester of plane trigonometry. In grade twelve, the students with the best records in mathematics should take a one-semester course in solid geometry and the elements of spherical trigonometry, with applications to celestial navigation and geography, and a one-semester course in *very* advanced algebra similar to college algebra.

5. *A general viewpoint concerning applications.* All courses should emphasize the *attitude of applied mathematics.* However, this may not be feasible at particular places in the courses where fundamental theory is being developed. The teacher should expand his background along the lines of present war interest in order to be able to stimulate the students. Thus, map projections could be included in geometry; problems relating to vectors could appear in geometry, algebra, and trigonometry; applications to military affairs and industry should occur frequently.

6. *A review course or special course for grade eleven or twelve.* Students now in grades eleven and twelve who have not taken at least two years of substantial mathematics should be offered a one-year or double-time-one-semester course in basic mathematical content.

7. *Laboratory teaching.* For all courses in substantial mathematics, it is recommended that regular *required* hours of supervised study be inaugurated so as to place the courses essentially on a laboratory basis.

My primary observation in connection with the long term effects of the war on secondary mathematics is that, aside from possible changes in the content of courses, the viewpoints which I have emphasized this afternoon are as important for the post-

war period as for today. I am proceeding under the assumption that, after the war, we shall be expected to make mathematics interesting and valuable for increased numbers of students from all parts of the intelligence scale. Hence, one of the most important of the war effects is that we must hereafter focus much more strongly on the necessity of teaching for *mastery*, in order that the students may get satisfaction from their courses. Therefore, a placement system of the type just outlined for war purposes remains essential in the post-war period. Moreover, with the aim of making mathematics really *valuable* to students, we must continue to emphasize *overlearning* at all places and not subscribe to attempts to create narrowly streamlined post-war courses.

To a certain extent, dependent on the degree to which our nation will remain militarized, we may find the high schools still under pressure to aid educational acceleration and military training after the war. In any case, the technical nature of the economy of the post-war period undoubtedly will put a measurable premium on the saving of wasted time at all levels in education. Hence, in the cases of intelligent students, I consider it proper to *oppose* attempts to delay starting substantial algebra and geometry until grade ten. As a related item in this direction, I believe that any pressure to install *narrowly socialized* courses in ninth grade mathematics, particularly for superior students, should be opposed in the post-war period.

My final comment on the post-war situation with respect to secondary mathematics is that the best minds in the fields of mathematics and the physical sciences should be enlisted to organize a substantial four-year program for the intelligent students which should have definite terminal aims as well as later collegiate uses. Of course, a program of this nature automatically would satisfy and might exceed any existing demands in regard to college requirements. The necessity for the organization of such a program is, in my mind, the principal war effect which we can anticipate in the following period of our national history.

"Many of our cities are still wilderness for thousands of small children in so far as the provision of constructive and real play opportunities is concerned. The menace of casual street associations is little realized by the taxpayers when they refuse to support well-planned playground activities." —*Cheney C. Jones* in *Social Work Year Book*, 1941.

FIELD STUDY—THE BACKBONE OF BIOLOGY AND CONSERVATION EDUCATION

Ralph W. Dexter
Kent State University, Kent, Ohio

Virtually every text of general biology introduces the first paragraph with a definition of the term "biology," and probably every instructor opens his course with a dissection of this word, explaining the derivation of its roots and then emphasizes once again that biology literally and actually is the study of living things. Any student who never reads beyond the first page of the text or does not continue after the first class hour knows that biology is the study of life. After this definition has been established, the instructor in a vast number of cases then proceeds to teach with the aid of pickled and dried specimens, stuffed animals, plaster models, charts, pictures, lantern slides, and other such paraphernalia—a course in *necrology*! As Wheeler[1] so aptly put it in his classical essay—"Every autumn we lay in a few cans of soused dog-fish and pickled sea cucumbers, coop up some guinea pigs, earthworms, cockroaches and fruit flies, throw in a bag of beans and several bales of hay for the botanists—and we are prepared for the worst." It is realized, of course, that preserved study specimens, materials of visual and objective education have their place in teaching a concrete subject such as biology, but they should be regarded by both teacher and student as merely aids in the understanding of the living organism.

Class study in many instances should be thought of as preparation for field study. Many teachers attempt to bring life into the course by maintaining aquaria, terraria, animal cages or window boxes in the laboratory. In all too many cases, however, these become ornaments or simply lend atmosphere to the class room. When used properly and made an integral part of the actual study program, they can be of great value in demonstrating the very essence of the subject. But, the study should not stop with these fragments of the outdoors brought into the laboratory. To study living things as such one must go out where plants and animals are living and observe them in their natural surroundings and in their ecological relationships. A pressed

Acknowledgment is made to Dr. H. A. Cunningham, Head of the Department of Biology, Kent State University, for a critical reading of the manuscript.

[1] Wheeler, W. M., "The Dry-Rot of Our Academic Biology," *Science* 57: 61–71, 1923.

plant or a bottled carcass isolated in a cabinet may help one to recognize the species when he encounters it later, but only as the student experiences the living organism in its natural habitat can he begin to understand and appreciate it as a dynamic organism. Obviously the ultimate study of biology, if it is to be *biology*, is in the field. While those phases of biology concerned with the internal relations (nutrition, respiration, reproduction, etc.) of the organism are not directly dependent on field study, one needs a basic understanding of the conditions under which these physiological phenomena take place since they all have external relations when carried to the ultimate analysis. During favorable seasons this field foundation can be laid in preparation for later laboratory study of internal relations. Beck[2] has raised some stimulating questions in regard to organizing biology classes on a seasonal basis by which the foregoing may be accomplished.

Studies conducted by Tinkle[3] and Stevenson[4] demonstrated that about one half of the high school biology students questioned had not been taken on class field trips. The report of Tinkle showed that in the opinion of the students one quarter of the teachers involved were not well prepared for conducting field studies. Student comments on the Stevenson questionnaire clearly showed that when field trips were successfully conducted they were the most valuable, enjoyable, and worthwhile portions of the class work. The field work also brought the students face to face with more actual science and contributed most to teacher preparation. An article by Washton[5] mentions that 93% of nearly 1200 pupils questioned felt that their study of biology would have been more interesting if outdoor classes had been held. Schellhammer[6] demonstrated experimentally that field trips enlarge the student's learning process to a measurable degree.

According to Sinnott in a recent report,[7] which is an excellent extensive study of the teaching of biology in secondary schools, it was learned that 42.5% of the schools studied do not include

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[2] Beck, P. V., "Our Changing Biology," *Sci. Ed.* 26(1): 26–31, 1942.

[3] Tinkle, W. J., "Field Trips in Biological Courses," School Sci. and Math, 33: 947–950, 1933.

[4] Stevenson, E. N., "Questionnaire Results on the Value and Extent of the Field Trip in General Biology," *Sci. Ed.* 24(7): 380–382, 1940.

[5] Washton, N. S., "Findings in the Teaching of Biology," School Sci. and Math. 41: 553–558, 1941.

[6] Schellhammer, F. M., "The Field Trip in Biology," School Sci. and Math. 35: 170–173, 1935.

[7] Riddle, Oscar, F. L. Fitzpatrick, H. B. Glass, B. C. Gruenberg, D. F. Miller and E. W. Sinnott, *The Teaching of Biology in Secondary Schools of the United States*, Pub. by Union of Amer. Biol. Societies, 1942.

field trips at all as a part of the class procedure. If those classes in which but a single trip or poorly managed field work were included, the percentage would undoubtedly be very much higher. Many students finish their courses in biology without having studied a living organism—others see only potted plants and a few aquarium animals or a spectacular specimen brought in for exhibition. Altogether too few get to see common living things in their natural surroundings and become familiar with them as such. The conclusion must then be reached that at least one half of the students enrolled in high school biology are not in the literal sense studying biology at all.

This same criticism can be extended to many college classes as well. While many courses in biology at the college level are highly specialized, and presumably are taken by students who are already oriented in the general field of biology, the colleges in many cases fail to lay a foundation of field experience with living things before the student advances to more highly specialized study based upon laboratory techniques. Two unfortunate conditions result. First, the student is often totally unaware of the nature and life history of the organism on which he is making intensive studies. Secondly, the student who is preparing to teach biology builds an intricate superstructure of detail on a flimsy foundation of knowledge of the living organism itself—and this is very often perpetuated in his own teaching. Fitzpatrick in a chapter on "The Training of Biology Teachers" in the report already mentioned states that in regard to criticism of their own training, "field work was mentioned again and again as something that had been neglected. Specific reference was also accorded to genetics, *ecology*, and *work with conservation problems*." It is apparent that the colleges have neglected Wheeler's (ibid) admonition that "they should be fed during the first year on the simple oat-meal pap of ecology." (Ecology used in this quotation in the sense of natural history.) A recent book review[8] has shown how few of the general college texts of biology give adequate attention to ecology and its application to conservation. No more than half of the general texts include a satisfactory discussion of ecology, and only a few deal with conservation. Some of the most recent texts are including ecology, but unfortunately only a few of these have done so successfully.

Field study has long been taught in the form of "nature

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[8] Dexter, R. W., "Ecology in Recent Biology Texts," *Ecol.* 23(3): 377–378, 1942.

study," especially in the elementary schools. Bartsch[9] laments that the spirit of nature study is fast disappearing from our schools. Excellent articles advocating a return to the study of living things at all levels of our educational system have recently been published by Sears,[10] Conklin,[11] Ward,[12] and Palmer.[13]

In the past several years attention has been given to the role of conservation education in the public school curricula. It is widely believed that such instruction should be given throughout the school system and in all subjects which have any bearing on the field of conservation. Certainly the study of biology can contribute its share best through field work. (See articles by Weaver,[14] Rohan and Barlow,[15] Ward,[16] Palmer,[17] Fink,[18] Potzger[19] and especially the chapter entitled "Biology as the Foundation of Conservation Education" by H. B. Ward in the book "The Foundation of Conservation Education." This book is the most outstanding publication to date in its field.)

It is significant that many public museums are now engaged in the study and exhibition of living materials. Many museums conduct regularly scheduled field trips and excursions. They sponsor study clubs and outdoor summer schools. Some have established nature trails and maintain nature guides for conducted walks and tours. In the museum buildings, formerly archives of the dead, one will often find living specimens on display in aquaria, etc.; and where living material is not possible or feasible, realistic dioramas portray the life of a region or of a particular community. The tendency is away from dead curiosities and more attention is being given to the interpretation

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9 Bartsch, Paul, "Today—Yesterday—and Tomorrow in Nature Study, SCHOOL SCI. AND MATH. 37: 920–924, 1937.

10 Sears, P. B. "The Importance of Biology Teaching for Secondary School Pupils," *Amer. Biol. Teacher* I(4): 67–69, 1939.

11 Conklin, E. G., "Living Versus Dead Biology," *Amer. Biol. Teacher* 2(7): 165–168, 1940.

12 Ward, H. B., "The Role of Biology in Conservation Education," *Amer. Biol. Teacher* 2(8): 197–202 1940.

13 Palmer, E. L., "Field Biology in City High Schools," *The Teaching Biologist* 9(8): 141–144, 1940.

14 Weaver, R. L., "Recent Trends in Conservation Education," SCHOOL SCI. AND MATH. 38: 647–653, 1938.

15 Rohan, B. J. and G. Barlow, "A Program for Conservation Education in the Junior High Schools," SCHOOL SCI. AND MATH. 39: 408–415, 1939.

16 Ward, H. B., *ibid.*

17 Palmer, E. L., "Conservation Education in the Schools," SCHOOL SCI. AND MATH. 40: 226–237 1940; "Conservation Education and the Elementary School," *Sci. Ed.* 25: 131–134, 1941.

18 Fink, O. E., "Developing the Program of Conservation Education in Ohio," *Sci. Ed.* 25: 124–130, 1941.

19 Potzger, J. E., "The Role of Conservation and Sympathy in Nature Study," SCHOOL SCI. AND MATH. 42(6): 534–538, 1942.

of nature. In this, some modern museums are well ahead of many schools and colleges.

Because of the need for more emphasis on field study for high school biology and for introductory and ecological courses on the college level, it would be well to bring together points which make for successful field work.

1. Familiarity with Region. Before field trips can be planned for greatest efficiency and maximum returns for the time and effort to be spent in field teaching, one must be thoroughly familiar with the natural features of his region and the particular advantages offered at each locality selected for study.

2. Organization of Trip. A field trip should be as carefully planned as a laboratory demonstration or a formal lecture. The route should be worked out, time allowances computed, aims defined, and necessary materials assembled. Special instructions should be given at the beginning of the trip. Wood[20] has written an instructive article on the organization of field trips. Classes in large cities or those not located near favorable sites for short trips can best use week-ends for all day excursions. Small groups are best, and large groups should be subdivided when possible to keep each unit intact and of manageable size. Clark[21] has offered suggestions in that regard. Needless to say a follow-up discussion will clarify many points not grasped at the time of observation.

3. Objectives. Each trip or excursion should have definite objectives. It is a common experience that one sees only that for which he is looking. Aimless wandering results in nothing but general impressions and a hodge-podge of miscellaneous and unrelated observations. The instructor should teach in the field, but he should not use the field as a lecture platform. The academic knowledge learned in books and in the laboratory should be applied to the study of the real, living organisms. The number of objectives should be limited in relation to time and ability to cover them well. Preferably the objectives of any one trip should be related. Of course, advantage should be taken of unpredicted observations of unusual interest which may come up, but these should not obscure the set objectives nor divert the original plans.

4. Attitudes. One of the most difficult and yet most important

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[20] Wood, Dora, "Planned Field Trips—An Integral Part of Science Units," School Sci. and Math. 41: 28–35, 1941.

[21] Clark, F. R., "Field Trips for Large Classes," School Sci. and Math. 32: 82–84, 1932.

aspects of field study is the development of proper attitudes. A field trip is neither a picnic nor a lark, but yet it should free the student from the rigid formality of the class room. Above all, the trip should not be regarded as a side issue or a holiday activity. Field study should be informal but taken seriously and considered an opportunity to observe the very heart of biology. The writer has found that lengthy field trips can profitably include a picnic as part of the day's program, but such activity should be bounded by certain time limits. Outside of these periods of relaxation, the student's mind and the topic of conversation should be directed toward the study at hand. Featherly[22] has enumerated interesting questions which might be brought up on a field trip. The spirit of adventure and investigation can hold interest as keenly as extraneous topics, and the thrill of discovery of common knowledge can be as exciting as an original discovery. Such first hand experience makes for lasting impressions.

The instructor also has proper attitudes to maintain. The recent report by Adams[23] is particularly good in establishing the standards and attitudes which should be held by the instructor.

5. Viewpoint of Ecological Interpretation. While some trips will necessarily be concerned chiefly with the identification and classification of plants and animals, field work should not stop with the compilation of a check list. Much more important is the interpretation of the landscape, of the biotic communities, of the dynamic forces shaping the landscape and controlling the biosphere. Special studies on individual organisms or of certain taxonomic groups or studies limited in scope should be related to the community or microcosm as a whole. An understanding of cause and effect relationships as an expression of natural laws and processes should be the ultimate goal rather than the mere listing of organisms or the study of isolated examples. The principles which they illustrate are more important than the materials themselves. Clausen[24] has shown how basic ecological laws can be made the focal point of field trips. Yothers[25] has established a long-time demonstration on abandoned land to teach high school classes the principles of succession.

With proper management field studies can become a thread

[22] Featherly, H. L., "The Biological Field Trip," *The Amer. Biol. Teacher* 2(6): 147–148, 1940.

[23] Adams, C. C., "School Museums, Field Trips and Travel as Phases of Objective Education," *N. Y. State Museum Bull.* 330: 75–116, 1942.

[24] Clausen, R. G., "The Plant-Animal Community," *Sci. Ed.* 20(2): 73–75, 1936.

[25] Yothers, L. R., "Field Study in Ecological Succession," *Sci. Ed.* 22(3): 143, 1938.

by which all of the other study activities can be united and bound together. Studies on ecological succession, seasonal changes, food cycles, effects of fire, disease, erosion and disturbance can be emphasized. Topics on the requirements of life and the obstacles of life become real situations in the field. Here can be studied the impress of the environment on living things and the balance which becomes established and reestablished in the biotic community. With those observations a foundation can be laid for the understanding of conservation of natural resources and its many problems.

The details to be considered, the time spent, and the depth of interpretation will of course depend upon the age and background of the students. Below the college level, only a general picture sketched in bold lines can be offered. Also, in classes of a general nature, there will be at times other points of view (reproduction, life histories, special taxonomic groups, etc.), but these can be related to the broad and comprehensive ecological interpretation which is being advacated here as the master point of view for field study.

6. Collections. If material is collected at all, it should be done so judiciously. Only materials which are needed for further study should be taken, and these should be maintained in suitable aquaria, terraria, etc., or properly preserved as permanent teaching aids.

7. Projects. For the more advanced students and the students with serious interests, supplementary projects can be suggested for individuals or small groups. Ullrich[26] has listed a number of field projects adaptable for teacher training institutions. Sequin[27] described a nature trail project for junior high school pupils while Breukelman[28] has demonstrated the teaching value of conducting stream studies with high school classes. Special projects are of greatest value when organized and written up in the form of a report.

8. Training and Experience. Training and experience are both essential for the development of good techniques in conducting field trips and promoting field study. Summer schools of natural history, biological stations, conservation camps have been established to further the study of field biology and con-

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[26] Ullrich, F. T., "Individualized and Vitalized Instruction in Biology in Teachers College," *Sci. Ed* 20(4): 189–192, 1936.

[27] Sequin, Hazel, "Building a Nature Trail as a Summer School Project," *Sci. Ed.* 20(3): 160–162, 1936.

[28] Breukelman, J., "The Biology of the Stream," *Amer. Biol. Teacher* 4(5): 143–149, 1942.

servation. Vinal[29] has promoted nature study counciling as training for public school teachers. Geist[30] has reported on the organization and activities of a unique camp for the training of teachers in the principles of conservation education. Two issues of the *American Biology Teacher* (October, 1941 and February, 1942) were devoted to the subjects of field trips and nature study, while two issues of *The Teaching Biologist* (May and October, 1940) were devoted entirely to matters of nature education. Even more significant is the fact that the 1942 Spring Outing of the association which sponsors this latter journal took the form of field trips in which stress was purposely given to ecological relationships rather than to haphazard collecting and identification. This "new type" of outing, as the announcement read, was conducted by outstanding biologists for the training of teachers in techniques of field study.

From a historical point of view, Wheeler (ibid.) likened natural history and field study to a stolon from which all of the various phases of biology have sprouted. An attempt has been made here to show that from an educational point of view field study is the very backbone of biology and its role in conservation education.

[29] Vinal, W. G., "The Value of Nature Leadership in Camp as Training for the Teaching of Elementary Science," *Sci. Ed.* 19(1): 16–19, 1935.

[30] Geist, D. E., "A New Venture," *The Teaching Biologist* 10(5): 85–87, 1941.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS FIFTH SUMMER CONFERENCE

The fifth annual summer conference of the New England Association of Chemistry Teachers is scheduled for the last week-end in August, Friday evening to Monday evening, August 27–30 inclusive. It will be held at Phillips Academy, Andover, Mass., twenty-three miles north of Boston, which may be reached conveniently by train and bus. The program will be centered on two main themes: (1) Strategic materials and (2) Chemistry teaching in the war effort. Under this latter topic considerable attention will be devoted to the participation of the chemistry teacher in civilian defense activities. It is also planned to offer a work-shop on lecture demonstrations to run throughout the conference.

While the summer conferences are held primarily for the benefit of members of the Association, anyone interested will be heartily welcome. Families of teachers will find much of interest in Andover. The Addison Gallery of Art and the Archaeology Museum on the Phillips Academy campus are outstanding in their fields. Adjacent to the campus is the 90 acre Cochran Bird Sanctuary. The outdoor and indoor swimming pools will be available to those who register. Communications concerning the conference should be addressed to the committee secretary, Amasa F. Williston, B.M.C. Durfee High School, Fall River, Mass.

THE LOCUS OF A FOCUS

Hollis D. Hatch
English High School, Boston, Massachusetts

It is always a question with elementary classes how exact we should be about our Physics laws and explanations. Admittedly we must not take the pupil out of his depth yet we often wish to study phenomena which are not simple. One solution is for teacher to figure out a simple explanation; how well he does this and still says close to the facts is a complement to his ingenuity.

A case in point is the concave mirror. In the article by Mr. Dwight (School Science and Mathematics, vol. 42, p. 627) all rays parallel to the principal axis reflect through the "focus" which is dutifully half the radius from the mirror. Conversely the rays coming from the "focus" all reflect parallel to the principal axis. Now for many concave mirrors this is more false than true; most textbooks state the above is true in the paraxial region but do not say where this is. The student naturally blunders blithely all over the mirror. The rest of this article is to determine the real direction of rays from a concave mirror by a simple yet accurate method.

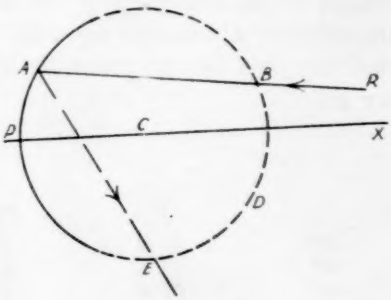


Fig. 1

Have the student draw a circle, mark its center, C, draw a diameter PX to be the optical principal axis, and a line RA representing the incident ray meeting the part of the circle representing the mirror. The question next is to determine the direction of the reflected ray assuming only that the angles of incidence and reflection are equal. Lay a ruler on the circle so its edge is the diameter through A and C. Where the ruler meets the circle is D but I suggest the student does not mark the point, only place the point of his drawing compass there. Set the compass to the distance DB and swing it to the other side of D making $DE = DB$. The arcs measure off equal angles on each side of the diameter AD and measure equal angles of incidence and reflection. AE is the reflected ray. The actual diagram need have no letters

upon it to emphasize the incident and reflected rays. Several rays may be plotted without confusion. The method makes no assumptions so is correct for any ray.

Now the student has a dependable method by which he can investigate his concave mirror. Let us see what the books mean when they talk of rays "near" the axis. Have the student draw a circle three inches or more in diameter and trace three or more rays parallel to the axis PX at different distances from it. The rays need not be actually parallel; it is quite enough for them to look parallel; construction would complicate the figure, not improve the results, and divert attention from what we want to find out i.e., to where these rays converge. A careful diagram shows that the rays at a small angle to the axis reflect through the axis at about half the radius of curvature, the other rays reflect so as to cut the axis nearer and nearer the mirror.

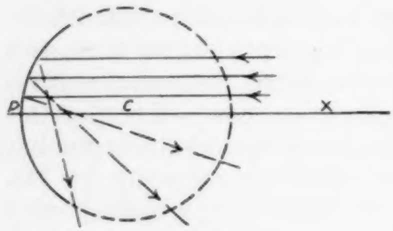


FIG. 2

The teacher may wish to know a little more of the mathematics of the above. If "f" is the distance from P to the axis intercept of a reflected ray and "i" the angle PCH of the incident ray, it is easy to prove $f=R(1-1/2\cos i)$. In tabular form we get:

i	f
0°	.50 R
10°	.49 R
20°	.47 R
30°	.42 R
40°	.35 R
50	.22 R
60°	.00

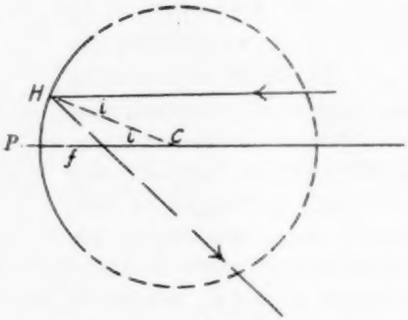


FIG. 3

This shows more exactly what the students found by diagram and what is meant by paraxial rays having a focus at .5 R. Note that when the incident parallel ray makes 60° with the mirror

the ray reflects to the pole to emerge finally parallel to the original path. Above 60° the multiple reflections end with diffused rays. Thus a half circular concave mirror, often thought of as converging, is roughly converging for 60° of arc, uselessly converging for another 60°, and diffusing for 60°.

The teacher may now discuss in general or mathematically, the effect of R on the focus. The curved mirrors at pleasure resorts give humorously distorted images by using short radii; reflecting telescopes use short arcs of long radius for austere images of the universe.

We are now ready to construct images with the student. The teacher may choose whether to get the image of an object anywhere including the distorted cases or to take only the undistorted ones. Let me point out that most teachers locate the two ends of an image and then draw a straight line connecting them. This ostrich-like method always gives an "undistorted" image —but it isn't what you really get in the mirror. If the teacher picks a distant object and rays from it that meet only the paraxial region (20° from axis ?) the usual methods give a correct result.

A better way, I believe, is to take two rays from the ends and center of the object. The teacher decides how much of the mirror is to be used; a small section near the pole giving straighter images than a large arc will. The rays taken are not drawn at any special angle but are drawn to the mirror one above and one below the principal axis. Joining the three image points with a smooth curve gives a correct idea of the image. This method has the slight advantage of being similar in idea to the methods used in advanced optics.

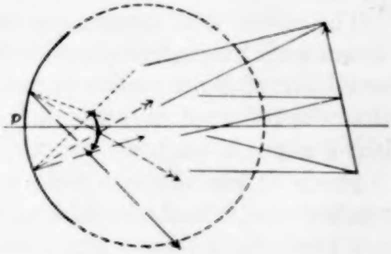


FIG. 4

An interesting and useful case is of rays emanating from a point $\frac{1}{2}R$ from the mirror. It can be easily studied by the above geometrical method. Have the student start with a ray from S making a small angle of incidence: it leaves the mirror practically parallel to the axis. But as rays are drawn at greater incident angles the reflected rays bend more and more toward

the principal axis until when the angle of incidence is 30° the reflected ray cuts the diameter at an angle also of 30° and at the end of the diameter on the circle. The mathematical relation between the angle of incidence and the angle of deviation (d) from parallel is $\sin (2i+d)=2 \sin i$. A trigonometry teacher will find this equation an example of where multiple values of the sine must be used to get a complete solution of the angles.

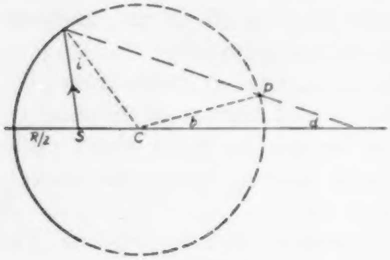


FIG. 5

If we consider where the reflected ray cuts the mirror circle we have a nice example of a maximum. The small angles of incidence give a reflected ray cutting the circle at P just above the axis. As the angle of incidence increases the reflected ray is reflected from points further up from the axis but the spherical aberration effect just noted works the opposite way to bend the ray downwards. The net result is that P moves up to a maximum height and then recedes. The exact point may be found from the equation: $\sin (3i-b)=2 \sin i$. Getting the maximum for b in terms of i is a nice calculus problem.

The above is of course the case of a headlight reflector. It shows why half spherical mirrors are not used, instead why a small arc of large radius is better. The last discussion shows that the reflected rays use only the center part of a headlight lens if a lens is used.

Much of the above article has been for the benefit of the teacher who I think should keep a little ahead of the pupil. The real idea which I hope you have gotten is that here is a method so simple any high school student can use it and study reflections in mirrors accurately without incorrect assumptions.

NEW COMET DISCOVERED

A new comet has been discovered by Miss L. Oterma, Finnish woman astronomer of Turku Observatory, who is credited with discovering two comets last year.

The comet was first seen on April 8 in the constellation of Virgo, which is now easily visible in our evening sky. It is of the fifteenth magnitude and therefore far too faint to be seen without telescopic aid. The new comet is near the celestial equator and moving slowly westward.

SOME SUGGESTIONS FOR THE IMPROVEMENT OF SCIENCE TEACHING

RALPH B. DELANO
499 Huntington Avenue, Boston, Massachusetts

The number of high school students studying the subject of physics has decreased from 23% in 1895 to approximately 6% during the past few years. In an attempt to determine some of the reasons for this decreasing enrollment, an objective test of 300 questions was given to one thousand students in four different school systems.*

The concept of friction was selected for this test because it is a transcendent which is comparatively easy to define and understand. In addition to being inherent in practically all matter in motion, friction touches, to a great extent, the experiences of children in Grades VII to XII.

Some of the minor problems under investigation were the grade placement of material for objective teaching, the superiority of country children over city children, the effects of sex differences, the comparison of ninth grade children with twelfth grade children, the determination of an accentuated period of scientific observation, the changes in scientific interest on the six higher grade levels, and a study of the applications of science which interest children in each grade.

The results of these tests show clearly that the different portions of a major concept can be most easily imparted on different grade levels. If this is generally true, it indicates that determinations of the grade placement of all important concepts should be made before science teaching can become scientific.

This investigation seems to indicate that we are destroying interest in science at the very beginning of instruction whenever we do not start at the proper level. Because of lack of understanding, students often develop an aversion to a subject before they have a chance to learn its possibilities. This unnecessary antipathy is very difficult to overcome and may fundamentally change the life work of the student.

The average boy's knowledge of friction so greatly exceeds the normal girl's knowledge that, in this field, instruction for boys should be on an entirely different level from that given to girls. If investigations, which may be subsequently conducted,

* R. B. DeLano, Doctor's Dissertation, "The Acquisition of the Concept of Friction," Boston University School of Education, 1942.

give evidence of the fact that this is true regarding other major concepts of the subject, we are reasonably safe in assuming that the inception of instruction of both boys and girls on the same level is one of the causes which have practically eliminated the subject of physics as an elective for girls.

This investigation indicates that some 9th graders know as much as the average 12th graders and that country children are not superior to city children as judged by their knowledge of friction.

There is no period in the development of the child where scientific observation is accentuated and, as a rule, the chief scientific interests of children remain constant from Grade VI through Grade XII.

A decrease in interest in friction and resulting scientific observations occurs in Grade XI. This is especially true in large city schools.

The airplane represented the chief scientific interest of the boys who took this test, and the camera was the primary interest of the girls.

Certain minor concepts, which remain constant or give evidence of no uniform increase in knowledge on the higher grade levels, are probably of little importance. While this static condition may be due to lack of observation, it is probably safe to assume that the student has but little use for information of this type. It is a serious mistake to include these topics in courses gives to non-college students.

The complexity of experiences, as judged by the knowledge of friction, was less on the lower grade levels than it was on the higher grade levels.

ALASKAN CARIBOU SUGGESTED AS ADDITIONAL SOURCE OF MEAT

An additional, untapped source of meat exists in the domesticated caribou (reindeer) herds of Alaska. Dr. William H. Hobbs, emeritus professor of geology, University of Michigan, suggests in *Science:*

The domesticated herds in Alaska number from 50,000 to 100,000, with millions more in wild herds in Alaska and Canada, Dr. Hobbs states. Caribou meat, in his opinion, surpasses the best venison and the best beef in taste, having something of venison's gamy flavor with a juiciness more like that of beef.

"As the domesticated herds are largely in northwestern Alaska near the Bering Sea," he points out, "it would be possible to ship the refrigerated meat by sea to our bases in the southwest Pacific and to our own Pacific ports."

THE CHICAGO COURSE OF STUDY IN ARITHMETIC

Turner C. Chandler
Principal, Burnside School, Chicago, Illinois

During the past twenty years the subject of arithmetic in the elementary schools has been the theme of hundreds of experiments, investigations, and studies; on the topic countless articles and scores of books have been written; textbooks have been given an entirely new form and have undergone major revisions in content. In keeping with this general interest in arithmetic each of the three superintendents of schools in Chicago since 1924 has been concerned with the topic.

William McAndrew emphasized computational accuracy. He insisted that the work be checked and 100% accuracy secured. It was during his administration that the educational world was emphasizing tests of mental ability and the homogeneous grouping of pupils in accordance with test results. This philosophy was reflected in the courses of study prepared under his direction. The course in arithmetic, like the courses in other subjects, listed items and exercises for the slow, the average, and the bright pupil. The course was sent out in mimeographed form and announced as a tentative course. Throughout his term committees continued to study and experiment with the material.

William J. Bogan early in his administration approved a new course of study in arithmetic. On February 27, 1929, this was approved officially by the Board of Education and printed in looseleaf books, one for grades 1–3, one for grades 3–6, and one for grades 7–9. The first two were prepared by a committee representing the elementary schools and the second by a committee representing the junior and senior high schools and the elementary schools.

William H. Johnson upon becoming superintendent of schools made arithmetic one of his many major interests. Early in his administration he appointed a committee under the chairmanship of J. T. Johnson of Chicago Teachers College to prepare a new course of study in arithmetic. This committee through the assistant superintendent in charge of elementary schools was given at least two specific points that must be incorporated into the new course. These two points with reference to the nature of the work for the first and second grades and with reference to

the grade placement of long division were insisted upon because recent studies had indicated the undesirability of formalized arithmetic in the first and second grades and had proved the lack of readiness of fourth grade pupils for long division. In general the superintendent left the committee free to prepare the course of study. Its work was mimeographed and sent to the schools in 1937. Principals and teachers were asked to experiment with the course and to send suggestions for changes to the chairman. He not only carefully considered these suggestions but also conducted experiments in the schools to determine the workability of the course. In 1939 a revised form was mimeographed and sent to the schools. This course we now use.

Having given this brief history of the course I now propose to enumerate some of the features found therein, to compare these with corresponding ones in the old courses, to evaluate them by the standards of the recent literature on the subject, and to inquire concerning the extent to which the course should be revised to meet the standards of more recent literature and the demands of the Army, the Navy, and industry that greater emphasis be placed upon mathematics in our schools and colleges.

Any course of study should have an underlying philosophy either explicitly expressed in the introduction and other explanatory matter and reflected in the entire content or else implicity expressed in the content. It is much easier to express a philosophy in an introduction than it is to put it into practice in the body of the course. The philosophy of a course, therefore, must be determined not by what is in the introduction—which unfortunately many teachers never read—but by the body of the course.

Some of the points which makers of a course in arithmetic should decide upon before beginning the actual writing are: whether the course is to be a suggestive outline to be adapted and changed to suit the varying needs of schools and classes or to be a detailed and rigid course to be followed by all; the relationship of the course to the texbook used in the school; the extent to which the course shall determine methods of teaching; the relative emphasis to be placed upon computation and drills, upon information, upon social values, upon training in quantitative thinking, and upon so-called disciplinary values; whether child needs and immediate values or adult needs and ultimate values shall prevail; where formal arithmetic is to begin; the

principles by which grade placement shall be determined; the extent to which large units are to be broken into component parts for different grade placement; provisions to be made for reviews; whether the main emphasis is to be placed upon mastery and accuracy of computation or upon thinking and understanding of general principles; provisions to be made for individual differences; and the relationship of the course to pupil failure.

The 1939 Chicago Course is in mimeographed form on $8\frac{1}{2} \times 11$ paper, one booklet for grades 1–2; one each for grades 3, 4, 5, and 6; and one for grades 7–8. Each booklet has a table of contents, a general introduction, a statement of the departures made in the course, and an introduction for the particular grade. There follows an outline of from three to seven pages indicating the work for each semester. For each semester one or two of the units are written up in detail to indicate the teaching procedure. For each semester there are three prognostic tests and at the end three diagnostic tests. Each booklet closes with a bibliography of about three pages. In general there are about forty pages for each grade.

The first feature of this course to be noted is that it is intended to be a "minimum course." This was also the case in the 1929 course. The Foreword of the 1929 course says, "The course as written is a minimum course. This means that where a group or part of a group of children is capable of going beyond the limits of the grade, the teacher is at liberty to enlarge upon the course in an anticipatory way, but no teacher should exact of her grade mastery of items in the next higher grade." The introduction of the 1939 course says, "The following syllabi specify the minimum essentials which should be mastered in each semester . . . It is understood that since the syllabi outline minimum essentials only, the brighter pupils do much more than is outlined therein. The detailed units given in the syllabi indicate the various ways how provision is made for enrichment material for the more able pupils." Thus the makers of the two courses had the same point of view concerning the matters expressed and implied in the foregoing two quotations. The courses are set up as rigid requirements. They outline the minimum essentials only. The implication is that these minimum requirements are keyed to the ability of the poor pupils. The statement is made that bright pupils do much more than is outlined in the course and that the detailed units indicate ways of

providing for enrichment. If this is a minimum course, then not only the brighter but also the average pupils should do more than is outlined. I have no objective data on this point, but general observation through the years of pupils in my own school who have come from other schools together with discussions with teachers and principals has convinced me that the brighter pupils do not do much more than the required essentials. Certainly the average pupils do not. Teachers in general, in my opinion, have accepted this course as a course for average pupils. Furthermore, only a few of the units are given in detail, and even here very inadequate provision is made for enrichment. For example, in the 4B semester the unit selected for detailed treatment is the one on subtraction where the minuend figure is smaller than the subtrahend figure. The enrichment work called "Extra Credit Exercises" consists of two sets of five problems each. The unit on uneven division by two is given in detail. For this no enrichment is indicated. No unit for 4A is given in detail. In the 5B semester the unit on the concepts of fractions as parts of the whole is given in detail. Nothing is said about enrichment. In the 5A semester the unit on subtraction of common fractions and mixed numbers with like denominators is given in detail. Here, as in 4B, two five-problem sets of examples are given. In each set two problems are computational and three are verbal. These illustrations are typical of the other semester grades. It may, therefore, fairly be said that this is in truth a minimum course, that it makes inadequate provision for additional work for the average and brighter pupils, that what provision is made is in the nature of additional work of the same kind, and that it suggests no philosophy to guide the teacher in preparing work for the bright pupils.

During recent months much criticism has been directed at the schools by those concerned in the war effort. The charge is made that those entering the armed services are not adequately prepared in the fundamentals of mathematics. One of the specific criticisms is that the schools have catered too much to the average citizen. Our course in arithmetic, it seems, does just this. To say this is not to criticize the committee that made the course or the administrators under whom it was made. The committee was directed to prepare a minimum course as quickly as possible to correct some of the points with which the old course and recent educational philosophy were at variance. This the committee did, and more. The criticism is directed first to those

teachers who permitted a minimum course to become a maximum course. It is directed more specifically to the general public for so overcrowding school rooms that individual differences could not be cared for and to parents who were more concerned with their children getting a "good mark" than with getting an education in keeping with their ability. Colonel B. W. Venable, of the Army's General Staff in Washington, D. C., recently said that more effort should be required of every student. The Army and the Navy want young people taught to use all the effort of which they are capable and to form the habit of persistence. I have dwelt somewhat at length upon this point, because I feel that here lies one of the crucial weaknesses in our recent educational practice. Administrative officers and bureaus of curriculum can not alone change this situation. The ultimate solution lies with classroom teachers and with parents.

The second feature of the course in arithmetic is the elimination of formal work from the first and second grades. The 1929 course included a considerable amount of formal work in the second grade. The 2A work included adding two two-digit numbers with no sum over 10, adding four one-digit numbers with no sum over 12, subtracting two-digit numbers without borrowing, multiplication facts with products up to 12, and the corresponding division facts. In 1937 all formal work was taken from grades 1 and 2. In 1939 the 45 easy addition combinations were included in the second grade. The course gives directions for teaching combinations in meaningful situations. Though all other formal work is eliminated arithmetic is not. As a matter of fact the course is far more comprehensive than the old course. It is probably the strongest part of the entire course. Arithmetic readiness is built up through new experiences, conversations, stories, compositions, school routine, handwork, school and home activities, and the various school subjects. Thus vocabulary and concepts are enriched and quantitative experiences broadened. Skills are developed as a byproduct. And, what is most important of all, the children become interested in and form the habit of using numbers. To reach these ends the course lists large numbers of suggestions in counting, telling time, recognition of numbers, writing numbers, using money, fractional concepts, and number experiences in connection with the various school subjects. Detailed procedures are given for use of numbers and quantitative thinking in the social studies units on the playhouse and on the post office and on the keeping of

records in connection with health. Any alert teacher who will get the point of view of this course will find her day full of opportunities to develop number sense.

J. Kadushin, of the Education Department of the Lockheed Aircraft Corporation of Burbank, California, recently wrote, (*Mathematics Teacher*, October, 1942) "Antipathy toward mathematics is so pronounced and so evident in all our contacts with employees in industry that sometimes we are prone to wish that our schools would leave mathematics out of their curriculum." He then points out that around Burbank there are some 200 supplementary training classes, but only two in mathematics, despite the great need. This antipathy of which Mr. Kadushin writes began no doubt in many cases in the early grades due to pupils being forced to do formal number work before they were ready. The type of work suggested by the Chicago course will do much to prevent the development of antipathy and will foster the natural interest that most children have in numbers.

It might be noted here that there has been a rather general interest in recent years in mathematics in the lower grades. In 1939 the Committee of Seven of the Northern Illinois Conference on Supervision began to hold conferences with teachers in the Chicago area and to collect the number experiences of children in the kindergarten and lower grades. Hosts of teachers were eager to co-operate. Experiences were assembled under vocabulary concepts, counting, number symbols, putting number groups together and taking them apart, fractional parts and simple ratios, and measuring. These findings of the Committee of Seven seem to confirm the soundness of the point of view of the Chicago course for the first two grades.

The third feature of the course upon which comment may be made is the relative emphasis that is placed upon computation, upon information, upon social values, upon quantitative thinking, and upon disciplinary values. Since the literature of this phase of mathematics is abundant and available, it need not be reviewed here. Whether a course should be based upon the simple computational needs of children and of simple business or whether it should center around experiences involving quantitative thinking is an unsettled controversy. The Chicago course for grades 3–6 is almost entirely computational. The 4A course, for example, has a five-page outline giving the computational requirements in reading and writing numbers, addition,

subtraction, multiplication, and division. There is a one-page outline of measurement of time and of length. Here there is about an equal division among concepts, skills, and computation. Then there are three short paragraphs about problem solving. These paragraphs suggest that applied problems be used with each unit, that pupils be asked to make their own problems, and that many problems may be found in connection with measuring activities. In Grades 7–8 there are nineteen units, some of which are optional. For some of these the outline is so brief that the point of view is not indicated. But in general the division is about equal between computational and social units. The former include units on addition and subtraction of fractions, division of decimals, areas, volume, Case II in percentage, interest, equations. The latter include units on arithmetic in the home, insurance, taxes, and the story of measurement. The course omits any suggestion of many social changes that have taken place in measurements, as, for example, the supplanting of counting and measuring by weighing. The computational point of view is further illustrated by the detailed procedure for teaching volume in 8B. Listed as specific objectives are: "To find the volume and develop the formula for volume of each of the following: Rectangular prism; Right circular cylinder." Eight pages are devoted to an explanation of mechanically developing and applying formulae for prism and cylinder. Only the briefest suggestion is made of developing the concept of the meaning of volume. In general it may be said that the course as a whole is computational; its primary purpose is not to direct the teacher in developing concepts or understandings, to emphasize social values, or to train in quantitative thinking. It makes no suggestion of the development of mathematical imagination or of the use of mathematics for recreation. Maybe elementary arithmetic should attempt to do none of these things. Some writers so say. Certainly, many teachers find it difficult enough to secure a fair degree of skill in the minimum computations.

A fourth feature of this couse is found in the grade placement of the items included. The introduction of the course lists three departures that have been made from the traditional course. They are, in brief, formal arithmetic requirements taken from the first and second grade, topics moved up to a grade placement more in keeping with the child's mental development, and the selection of procedures in accordance with experimental evi-

dence. Each grade booklet has a bibliography, which presumably indicates some of the experimental evidence upon which grade placement was based. The work of the Committee of Seven of the Northern Illinois Conference on Supervision was very influential. In this connection it should be remembered that the recommendations of that committee are by mental age and not by school grade.

Some of the changes in grade placement from the 1929 course to the 1939 course are as follows: Easy addition combinations from 2B to 2A; the 45 easy addition combinations from 2A to 3B; completion of 100 addition combinations in 3B in both courses; completion of 100 subtraction facts from 3B to 3A; completion of 100 multiplication facts from 4B to 4A; completion of division facts from 4B to 5A; multiplication of two-place number by two-place number from 4A to 5B; beginning of long division from 4A to 5B; both courses complete division in 6A; addition of fractions with unlike denominators from 5B to 7B—the 1939 course having multiplication and division of fractions before addition and subtraction; subtraction of fractions with unlike denominators from 5B to 7B; multiplication and division of fractions from 5B and 5A to 6B and 6A; beginning of decimals from 6B to 5B; difficult phases of division of decimals from 6A to 7A; percentage from 6A to 7B for Case I and 7A for Case II; interest from 7B to 8B; and equations from 8B to 8A.

In the matter of measurement the two courses are not organized alike and so can not be so easily compared. A few points will suffice to indicate the difference in point of view of grade placement. In the 1929 course telling exact time is required in 4A; in the 1939 course certain phases of the measurement of time are listed in each semester of grades 3–6, but telling time to the nearest five minutes is not required till the 5A grade, and exact time is not required till 6B. In the 1929 course measuring distance in inches and quarter inches is required in 4A; in the 1939 course measuring in quarter inches is nowhere required specifically, but in 7B is specifically limited to measuring to nearest inch.

There is no great difference in the eighth grade courses. The 1939 course adds a unit on square root and a unit on the story of measurement, both of which are optional. Both courses have units on volume, insurance, banks and investment, equations, taxes, and the metric system. The last unit in the 1929 course is indirect measurement; in the 1939 course, scale drawing.

The introduction says, "The theme in this course, if a course of study may have a theme, is *teaching arithmetic with meanings*. The committee feels that advancing topics to a place where pupils are more mature will make it possible to make arithmetic a more meaningful and a more interesting subject, and at the same time obviate much of the drill for maintenance of skills that have no immediate use." The extent to which teachers have taken advantage of this opportunity to make arithmetic more meaningful and the degree to which the purposes here stated have been realized are matters too broad to be discussed here.

A fifth feature of the 1939 course is the breaking up of processes into parts for different grade placement. This feature is carried much further than in the 1929 course. Only one illustration will be cited here. In 3A we find multiplication combinations by 2 and 3 and multiplication by 2, 3, and 4. In 4B multiplication by 5 is added and in 4A multiplication by 6, 7, 8, and 9, the limit of difficulty being three-place multiplicand. In 5B multiplication by two-pace multipliers is added, the multiplicand being limited to two-place numbers. In 5A we have four-place multiplicands and two-place multipliers with three successive cases of carrying. In 6B three-place multipliers are introduced. The work of 6A is a review. This feature of the course thus confines the introduction of a process to computational factors that are relatively easy. This makes it possible to focus the attention on developing concepts and understandings. The process thus becomes meaningful to the pupil. Furthermore this feature automatically provides for review over as many semesters as those in which the process is included. This feature introduces, of course, many more topics into any one semester than would be the case if a single process were completed in one or two semesters. It is not uncommon, therefore, to hear teachers say that they do not have time to cover all the topics listed for the semester. It may be that the feature has been carried too far, but the theory back of it is sound.

The sixth point to which I wish to call attention is the relationship of the course in arithmetic and the textbooks available. It seems probable that authors of modern texts are quite as familiar with studies and experiments in grade placement as are teacher committees that write courses of study. Authors, of course, usually write books for nation-wide distribution and must, therefore, adhere more or less to the traditional in grade

placement. Authors can and have been, however, influential in changing grade placement. In general, effectiveness of teaching arithmetic in the classroom is greatly aided by changes in courses and in texts taking place at the same time. Certainly teachers are greatly handicapped when the course and the text do not have a high correlation in grade placement. This is the case in Chicago now. Since the 1939 course was adopted only one text has been available for purchase. The text itself claims two major objectives, namely, to develop computational skill and to develop understanding and appreciation. We have already said that the theory of the course is to begin a process with very easy computational factors so that the emphasis may be placed upon understanding. In a great many instances, however, the textbook material on developing the understanding is not available to the pupils and teacher because it appears in a lower grade book. A few examples will make this clear. In the course, division by 2 is in 4B. In the text it is in third grade. In the course, long division is introduced in 5B. The material to develop understanding in the Chicago text and in most other texts is in fourth grade. The addition of unlike fractions is in the 7B course. The explanatory material for this process is in the fifth grade book. In the seventh grade text no explanatory material is found and only a few review exercises. The handicap to which this situation puts teachers and pupils is obvious. The result is, whether it should be so or not, a tendency to make the unit mechanical and computational. Thus the very value sought in pushing topics up to higher grades is too largely lost.

Having given a brief account of the history of arithmetic courses in Chicago since 1924 and having indicated six points in the present course about which there are differences of opinion, let us, in conclusion, consider the need for a re-evaluation and a revision of our present course. All who have read the literature on mathematics since Pearl Harbor know the criticisms of the Army, the Navy, and industry. Earl H. Hanson in the October number of *Illinois Education* points out that some of this criticism is not justified in that the Army and Navy tests are given to all men in the service regardless of individual aptitudes. On the other hand, some of the criticism is justified. We have not taught persistence. Certainly not enough high school students have been taking mathematics. To what extent is the elementary school responsible for this?

On page 3 of the program for this convention is a letter from

the Superintendent of Schools of Chicago. He says, "Our government is depending on you to prepare our young men with the scientific and mathematical background necessary for Victory. The schools' standard of achievement must be high. No longer can a boy expect to just 'get by' on his math. He must have complete mastery of it is he is going to use it in the service of his country." I need not here point out the implications of this statement either with reference to those who take mathematics or to the great majority who take no mathematics after leaving the eighth grade. I do desire to point out that the literature is full of statements that there will be the same need for mathematics in industry after the war as there is in the armed services now—including mathematics for girls. It is our earnest hope that our present generation of elementary pupils will not be in the armed services. It will be their task to rebuild after the war. They will certainly live in an industrial and mechanical age such as no former generation has known. To do that rebuilding and to live successfully in that age will require mathematics quite as much as the social sciences and the physical sciences. The elementary school can not escape its responsibility for laying the foundation in mathematics for the new age. It seems that in Chicago the first step should be a re-examination of its course of study with reference to at least the following points: (1) Add to the minimum course definite provisions and requirements for average and better than average pupils; (2) Put into the course more emphasis upon making arithmetic meaningful and include suggestions to guide teachers in doing this; (3) Reconsider the grade placement of the topics in the course; (4) Extend the very excellent outline for development of number experiences in the first and second grades; (5) Consider whether or not there are items in the upper grades that might be omitted; (6) Suggest to the high schools that there might be included a required course in the ninth grade that would include some of the topics formerly taught in the elementary school; and (7) seek a closer correlation between the course and the texts to be used, and in cases where the two do not agree, prepares for the teacher more extensive guidance material.

The great majority of the Latin American universities are national institutions, and there are only a few strong private universities. Higher education, with few exceptions, is entirely free.—"*The Americas*"

MOLECULAR MODELS IN THE TEACHING OF CHEMISTRY

Saverio Zuffanti
Northeastern University, Boston, Massachusetts

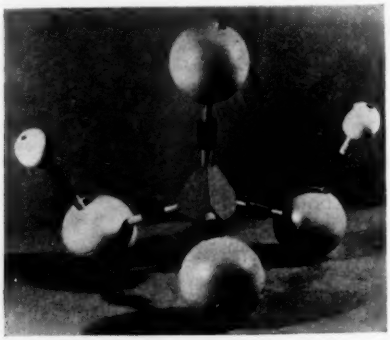
Molecular models are almost indispensable in the teaching of chemistry. From the viewpoint of both the teacher and the student they aid tremendously in the presentation of space relationships, restricted and free rotation, isomers, covalent and coordinate linkages, etc.

Too often the student acquires the habit of thinking in terms of a two-dimensional plane because of the blackboard or textbook presentation and completely ignores the three-dimensional spacial configurations of the molecules. This fact leads to many difficulties in the understanding of isomeric relationships and the different kinds of linkages.

Covalent and Coordinate Linkages

Many students would fail to recognize the model in picture A as a representation of the sulfuric acid molecule because he has been thinking in terms of a planar model presented to him, i.e.:

$$\begin{array}{ccc} H-O & & O \\ & \diagdown\ \diagup & \\ & S & \\ & \diagup\ \diagdown & \\ H-O & & O \end{array} \quad \text{or} \quad \begin{array}{c} O \\ \| \\ H-O-S-O-H \\ \| \\ O \end{array} \quad \text{or} \quad \begin{array}{c} \cdot\cdot \\ :O: \\ \cdot\cdot\ \cdot\cdot\ \cdot\cdot \\ H\ :O:S:O:\ H \\ \cdot\cdot\ \cdot\cdot\ \cdot\cdot \\ :O: \\ \cdot\cdot \end{array}$$



A

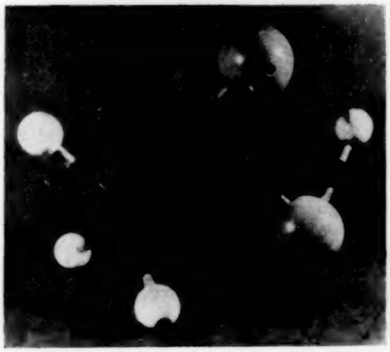
In this sulfuric acid model (Picture A) the sulfur atom is represented by a wooden tetrahedron (2″) that has been painted

yellow, the oxygen atoms by blue wooden balls (2″ d.), and the hydrogen atoms by white wooden balls (1″ d.). The coordinate linkages to two of the four oxygen atoms are represented by two yellow pegs (representing electrons) joined together with heavy-walled rubber tubing. The two covalent linkages to the other two oxygen atoms are shown by a yellow peg (attached to yellow sulfur atom) and a blue peg (attached to a blue oxygen atom) joined together by heavy-walled rubber tubing. The covalent linkages between the oxygen atoms and the hydrogen atoms are similarly represented by joining the white peg from the hydrogen atom and the blue peg from the oxygen atom with heavy-walled rubber tubing.

Single and Double Covalent Bonds

Picture B shows a model of the acetic acid molecule which is generally written as CH_3COOH or

$$\begin{array}{ccccccccc} & & H & & O & & & & \\ & & | & & /\!\!/ & & & & \\ H & - & C & - & C & - & O & - & H \\ & & | & & & & & & \\ & & H & & & & & & \end{array} \qquad \text{or} \qquad \begin{array}{ccccccc} & & H & : & O : & & \\ & & \cdot\cdot & & \vdots & & \cdot\cdot \\ H & : & C & : & C & : & O : H \\ & & \cdot\cdot & & & & \cdot\cdot \\ & & H & & & & \end{array}$$



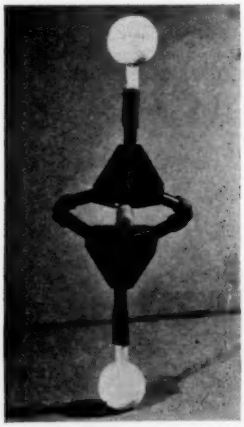
B

In this model (picture B) the two carbon atoms are represented by black tetrahedra (2″) made of wood and the four outermost or valency electrons of each atom are represented by four black pegs, one at each corner (the pegs are slit at one end to make a good tight connection with the atom). Three of the hydrogen atoms (white) with an electron (white peg) apiece can be seen connected to the carbon electrons with rubber tubing, thus making a covalent linkage in each case. The two carbon atoms are joined by a shaired pair of electrons (black pegs), one from each

carbon tetrahedron. One oxygen atom is connected to the second carbon tetrahedron by two covalent bonds; two electrons from the oxygen atom and two from the carbon atom. The other of the two oxygen atoms forms a covalent bond with the carbon atom and another single covalent bond with the fourth hydrogen atom. This model enables us to show single and double covalent bonds.

Triple Covalent Linkages

Picture C shows a model of the acetylene molecule ($H-C\equiv C-H$ or $H:C\vdots\vdots C:H$) in which we have a triple covalent bond, three electrons from each carbon tetrahedron joined to-

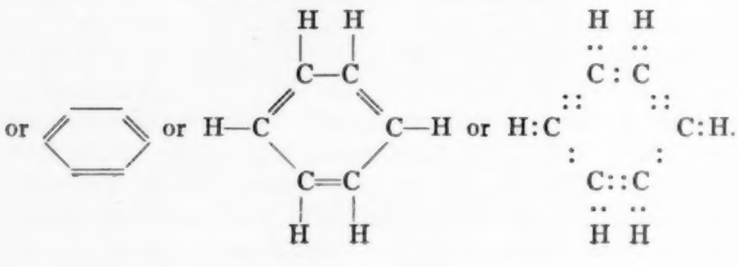


C

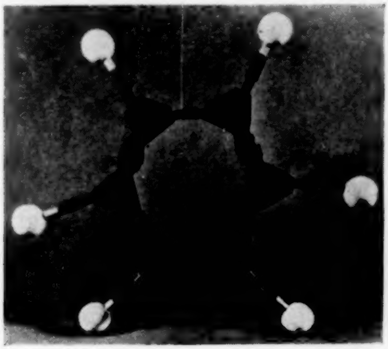
gether. The student can readily see here that there is restricted rotation where such a condition exists. He can also see that considerable strain is present and that it leads to increased chemical activity of such compounds

Cyclic Models

Picture D shows a model of the benzene molecule, C_6H_6



This model enables us to illustrate single and double covalent bonds. In the case of benzene this model also shows why the six carbon atoms and the six hydrogen atoms are all on one plane. In the case of cyclohexane where no double covalent bonds are present we can show the chair-form and the boat-form of the molecular configuration.



D

It is obvious that with the linkages formed by this method shown in these models that they lend themselves readily to the construction of rings of almost any size. Most all models that are sold restrict one to the formation of six-membered rings only.

The sizes of tetrahedra and balls used do not correspond in scale relatively to the actual sizes of the atoms that they represent, but the comparisons are close enough so that the facts are not greatly distorted.

Chelation and Hydrogen Bridges

It can be seen in some of the pictures that the balls representing the hydrogen atom have a second hole drilled in them at an angle of 180° to the first hole. This enables us to demonstrate chelate rings such as in salicylaldehyde, carboxylic acid dimers, and many other compounds of this type. We can also illustrate simple hydrogen bridges such as in the ammonium hydroxide

molecules $\begin{array}{c} H \\ | \\ H-N \\ | \\ H \end{array}\!\rightarrow H-O-H.$

Our set of models consists of: 50 black tetrahedra (carbon

atoms), 20 natural finish tetrahedra (nitrogen atoms), and 15 yellow tetrahedra (sulfur atoms) with the necessary number of colored pegs for each tetrahedron (4 for each carbon, 5 for each nitrogen, and 6 for each sulfur). All tetrahedra are 2″ on a side. The set also includes 100 1″ d. White wooden balls (hydrogen atoms), 20 2″ d. pale-blue wooden balls (oxygen atoms), 20 2″ green balls (chlorine atoms), 20 2″ brown balls (bromine atoms), and 20 2″ violet balls (iodine atoms). These balls all have pegs (electrons) colored to match the balls.

The students in my organic chemistry class have used these models and report that it has helped them considerably in understanding and visualizing the reactions we discuss in class.

In summary then, these models enable us to demonstrate:—(a) covalent single, double, and triple bonds, (b) coordinate linkages, (c) the tetrahedral nature of the carbon, nitrogen, and sulfur atoms, (d) free and restricted rotation, (e) chelation and hydrogen bridges, (f) isomerism of various kinds, and (g) rings of almost any size.

I will gladly furnish any additional information desired to individuals interested in the construction of these models.

STEERING WHEELS AND OTHER PLASTIC PRODUCTS MADE FROM REDWOOD WASTE

Auto steering wheels are among new plastic products made from redwood pulp described by Harry F. Lewis, dean of the Institute of Paper Chemistry, before the meeting of the American Society of Mechanical Engineers.

He told of extensive research at the Institute to reveal fundamental knowledge of the chemical composition of various parts of the redwood tree.

A tannin was found to be responsible for the longevity of the stately tree giants. This same tannin and related compounds in the wood can now be converted by a special cooking process to thermoplastic pulp.

Resins combined with the treated pulp yield a thermosetting composition that can be molded into bottle closures and similar plastic products.

RESEARCH IN ELECTRICAL COMMUNICATION WINS FRANKLIN MEDAL FOR GEORGE W. PIERCE

Outstanding contributions in the field of electrical communications and his influence as a great teacher have won the Franklin Medal for Prof. George Washington Pierce of Harvard University. The award was made at the annual Medal Day ceremonies of the Franklin Institute.

One of the most important discoveries made in radio during the past 20 years was made by Prof. Pierce. His research simplified oscillator circuits for use with quartz crystals and led to the use of the crystal as a means of holding a radio station on its assigned spot on the dial.

HUMANIZING CAREERS IN THE BIOLOGICAL SCIENCES

G. M. Relyea
University, Alabama

Careers in the physical sciences are receiving much well-deserved publicity these days. High school pupils are learning about them in what, it seems to me, is the best way—through reading in current newspapers, magazines, and books about the men and women who are following these careers successfully. Careers in the biological sciences, however, are not faring so well. Most pupils still hear about them only through reading dull synopses of the lives of famous biologists of the past in their biology texts.

Granted that these famous men should be studied for their contributions to biology, it is nonetheless true that the methods by which they entered upon their careers have little significance today. Pupils who show special interest in biology and who are trying to reach a decision on their future vocations need to know exactly how the people who are successful today in careers requiring a knowledge of biology "got that way." Were these men and women keenly interested in biology when they were young? Was there a particular event which precipitated the decision to enter a biological career? What pattern of education and special training did they follow? Is the vocation open at present? Does it provide a good living? Exactly what kind of work does a person do in it?

These are among the questions which are answered in the biographies and autobiographies of living successes in biological science careers. The list which follows includes for the most part books published since 1934, and all those starred have been found in public or school libraries. Those unstarred have been recommended by such authorities as the Index to Occupations, the Peabody Journal of Education, and the Standard Catalogue for High School Libraries, but have not been available to this writer. All biological science careers are not represented, but those which are have been classified according to the probable fields of interest in biology which high school pupils will hold.

These books may be used by biology teachers in various ways; as, for instance, these—

1. Source of ideas for free-reading by pupils already interested in a biological career of some sort.

2. Source of material for class reporting by class members or Biology Club members.
3. Source of material for special beginning or ending units in the Biology course.
4. Source of inspirational material for pupils who ask, "What good is Biology to me? I'm not going to teach or go into medicine."
5. Source of material for special reports on careers which coincide with the particular subject matter unit being studied in the Biology course.

BIBLIOGRAPHY ON CAREERS IN THE BIOLOGICAL SCIENCES

EXPLORING AND COLLECTING

a. Museum expeditions for facts, specimens, photos

*Andrews, Roy C., *This Business of Exploring*
N. Y., Putnam, 1935, 275 pp.
Author says book was written to answer these: "How can I be an explorer? What remains to be done in exploration?" The questions are fully and excitingly answered.

*Andrews, Roy C., *Exploring with Andrews*
N. Y., Putnam, 1938, 15 photos
Selections for younger readers from Andrews' writing. Chapter I tells how he became an explorer. Other chapters tell of his experiences in exploration.

*Akeley, Mary L. Jobe, *The Wilderness Lives Again*
N. Y., Dodd Mead, 1940, photos
Story of Carl Akeley and his work written by his wife and expedition-assistant. Gives good idea of life of a scientist, in exploring and in museum.

*Beebe, William, *Half Mile Down*
N. Y., Harcourt Brace, 1934, photos
Story of bathysphere descent, fish seen, difficulties of this type of exploration.

*Beebe, William, *Book of Bays*
N. Y., Harcourt Brace, 1942, photos
New findings for science in 1937–38 expedition of New York Zoological Society, in waters from California to Colombia.

*Beebe, William, *Exploring with Beebe*
N. Y., Putnam, 1932, photos
Collection of Beebe's writings especially interesting to younger readers.

*Carnochan and Adamson, *The Empire of the Snakes*
N. Y., Stokes, 1935
Smithsonian-Chrysler Expedition to Africa to obtain animals for the National Zoological Park in Washington.

*Ditmars, R. L., *The Making of a Scientist*
N. Y., Macmillan, 1937, photos
Autobiography of famous herpetologist and lecturer, fascinatingly told.

*Ditmars, R. L., *Strange Animals I Have Known*
N. Y., Blue Ribbon Books, 1931, photos

Strange and exciting adventures collecting and studying animals. Tells how he entered the career.

*Ditmars, R. L., *Confessions of a Scientist*
N. Y., Macmillan, 1934
Personalized account of adventures with bats, snakes, insects, etc.

*Ellsworth, L., *Exploring Today*
N. Y., Dodd, 1935
Exploration as a vocation; own experiences and advice on entering exploration today.

Gill, R. C., *White Water and Black Magic*
N. Y., Holt, 1940
Contains much material on the botany of the Upper Amazon.

Klingel, G., *Inagua*
N. Y., Dodd Mead, 1940
Story of the careful planning of an expedition, exciting chapter on wrecking of its ship, then its successful completion.

Morris, Ann, *Digging in the Southwest*
N. Y., Doubleday, 1933
Archeological adventures of woman with expedition in U. S. exploration.

Pope, Clifford, *China's Animal Frontier*
N. Y., Viking Press, recent
For young would-be explorers. Author was member of R. C. Andrews Third Asiatic Expedition.

Sanderson, Ivan, *Living Treasure*
N. Y., Viking Press, 1941
Study of animal life in jungles of Jamaica, British Honduras, Yucatan, etc., by leader of expedition. Amusing and scientific.

Von Hagen, V. W., *Jungle in the Clouds*
N. Y., Duell, Sloan, and Pearce, 1941
Rain-jungles of Honduras, in quest of the Quetzal bird of Indian legend. Much natural history as well as human interest.

b. Collecting of animals for zoos and circuses

*Buck, Frank, *All in a Lifetime*
McBride, N. Y., 1941
Autobiography written with help of Ferrin Fraser. Photos. Exciting.

Buck, Frank, *Animals are Like That*
N. Y., McBride, 1939
Experiences in capturing wild animals, photos.

*Buck, Frank, *On Jungle Trails*
N. Y., Stokes, 1936
Experiences in capturing animals alive. Very easy and fascinating reading. Photos.

*Thompson, R. W., *Wild Animal Man*
N. Y., Morrow, 1934
Story of Reuben Castang, procurer of wild animals of all kinds for zoos, etc.

c. Government service-plant explorer

*Fairchild, David, *The World Was My Garden*
N. Y., Scribners, 1939, photos
Autobiography of famous plant-explorer for the United States. Very well done.

THE ARTS AND THE BIOLOGICAL SCIENCES

a. Photography

*Chapman, Wendell and Lucie, *Wilderness Wanderers*
N. Y., Scribners, 1937, photos
Adventures in photographing and studying wild animals in the Rockies. Light style with exciting and interesting incidents.

*Craig, John, *Danger is My Business*
N. Y., Simon and Schuster, 1938, photos
Autobiographical account of Craig's work in undersea photography, still and movie. Considerable material on animals.

*Craighead and Craighead, *Hawks in the Hand*
N. Y., Houghton, 1939, photos
How the Craighead twins started their hawk-photographing hobby while still in teens. Experiences, procedures, etc.

*Johnson, M., Johnson, O., *Over African Jungles*
N. Y., Harcourt Brace, 1935, photos
Airplane exploration and photography in Africa by famous Johnsons. Some good advice on how to explore.

*Johnson, Osa, *I Married Adventure*
N. Y., Lippincott, 1940, photos
Autobiography. Very well done. Tells of meeting Martin Johnson, early struggles in photographing African wildlife, etc.

*Williamson, J. E., *Twenty Years Under the Sea*
N. Y., Hale, Cushman, and Flint, 1936, photos
Autobiographical account of his undersea photography in Williamson Tube, how he got into deepsea work, experiences, etc.

b. Painting, Sketching, Sculpturing

*Kirkland, W. and F., *Girls Who Became Artists*
N. Y., Harper and Bros., 1934
Chapter I Wanda Gag, Cats as artistic speciality.
Chapter III Marguerite Kirmse, Dogs as artistic specialty, etching.
Chapter X Anna H. Huntington, Horses as artistic specialty, sculpture.

*Leigh, W. R., *Frontiers of Enchantment*
N. Y., Simon and Schuster, 1938
Author was artist on Carl Akeley Expedition, and others in Africa. Tells of artist's work on explorations. Book illustrated with author's drawings.

*Seton, Ernest Thompson, *Trail of an Artist-Naturalist*
N. Y., Scribners, 1940
Autobiography. Book illustrated with many paintings and sketches by author. Well done.

*Sanderson, Ivan, *Animal Treasure*
N. Y., Viking Press, 1937
Autobiographical account of artist's work with animals in African expeditions. Many fine illustrations by author.

c. Writing

Many of the books listed under other headings tell of writing books, articles, children's books, about living things; as, Seton, Johnsons, Ditmars, Beebe, Pearson, Howard, etc.

Raising, Training, Caring for, Plants and Animals

a. Zoos and circuses

*Beatty and Anthony, *The Big Cage*
N. Y., Century, 1933, photos
How animal training is done; true and exciting incidents with animals in circus.

*Benchley, Belle, *My Life in a Man-made Jungle*
Boston, Little-Brown, 1940, photos
Experiences of a woman zoo director San Diego Zoo. Autobiographical. Photos.

*Benchley, Belle, *My Friends the Apes*
Boston, Little-Brown, 1942, photos
Sequel to above. Tells especially about the care of apes in the zoo, their intelligence, etc.

*Cooper, C. R., *Lions 'n Tigers 'n Everything*
Boston, Little-Brown, 1941 (rev.), photos
First-person account of training of animals for circus.

Lintz, Gertrude, *Animals are My Hobby*
N. Y., McBride, 1942
Tells how she raised such animals as St. Bernard dogs, chimpanzees, Gargantua, Massa, with experiences while so doing.

b. Farms and Ranches

Call, Hughie, *Golden Fleece*
N. Y., Houghton Mifflin, 1942
Author tells of experiences on Montana sheep-ranch. Gives idea of complexities of the occupation.

Cleaveland, Agnes, *No Life for a Lady*
Houghton Mifflin, 1941
Author tells of life since childhood on cattle ranch in New Mexico. Gives good idea of difficulties of occupation.

*Harris, Evelyn, *The Barter Lady*
N. Y. Doubleday Doran, 1934
First hand experiences of woman who cared for her five children and ran three farms alone and with no money to begin with. Gives realistic picture of life on a Maryland farm.

*Nall, T. Otto, *New Occupations for Youth*
N. Y., Association Press, 1938
Short chapters in which author interviews outstanding success in occupations. Farmer, page 20–27.

Provines, D. C., *A Home for Keeps*
N. Y., Longmans Green, 1937
Struggles in making a California fruit ranch pay for itself, fictionized.

Rak, Mary, *Cowman's Wife*
N. Y., Houghton Mifflin, 1934
Life on big cattle ranch in Arizona, troubles.

Rak, Mary, *Mountain Cattle*
Houghton Mifflin, 1936
Continuation of above.

*Smart, C. A., *R.F.D.*
N. Y., Norton, 1938
Author was literary man, then went to Ohio to run a farm. Tells experiences with buildings, animals, business, people, etc.

*Tetlow, H., *We Farm for a Hobby and Make It Pay*
N. Y., Morrow, 1938
Author's experiences on Medlock Farm in Pa., raising pigs, poultry, cows, etc., chances for success in farming, pitfalls, etc.

*Wilson, C. M., *Country Living Plus and Minus*
Stephen Daye Press, Brattleboro, Vt., 1938
Part-time farmer tells about his life on farm in Vermont. True stories of people from city who make good in country.

c. Forestry

*Nall, T. Otto, *New Occupations for Youth*
N. Y., Association Press, 1938
Woman forester, interviewed, pages 84–90.

Rush, W. M., *Wild Animals of the Rockies*
N. Y., Harpers, 1942, photos
First hand experiences of forest ranger. Many facts and stories of animals.

MEDICAL CAREERS

a. Doctors in the United States

*Baker, S. Josephine, *Fighting for Life*
N. Y., Macmillan, 1939
Autobiography of N. Y. C. woman doctor, pioneer in child hygiene work.

Clapesattle, Helen, *Doctors Mayo*
University of Minnesota, 1941, photos
Well told story of these famous doctors.

*Hertzler, A. E., *Horse and Buggy Doctor*
N. Y., Harpers, 1938
Autobiography of country doctor. Humorous account which gives fine picture of recent and present tasks of general practitioner.

Jerger, J. A., *Doctor, Here's Your Hat*
N. Y., Prentice-Hall, 1939
Autobiography of a family doctor.

*Morris, R. T., *Fifty Years a Surgeon*
N. Y., Dutton, 1935
Autobiography of famous surgeon.

*Morton, Rosalie Slaughter, *A Woman Surgeon*
N. Y., Stokes, 1937
Autobiography of famous woman surgeon. Excellent.

Regli, Adolph, *The Mayos, Pioneers in Medicine*
N. Y., Messner, 1942
Biography of these three famous men.

*Withington, Alfreda, *Mine Eyes Have Seen*
N. Y., Dutton, 1941
Reminiscences of woman doctor, which like some of the books above, gives idea of struggles of medical pioneers.

b. Doctors outside the United States

*Basil, G. C., *Test Tubes and Dragon Scales*
Philadelphia, Winston, 1940
First-person story of a doctor in China.

*Heiser, Victor, *An American Doctor's Odyssey*
N. Y., Norton, 1936

Autobiography of doctor famous in public health work in U. S. Govt. possessions.

*Lambert, S. M., *A Yankee Doctor in Paradise*
Boston, Little Brown, 1941
Author's work in Papua, Fiji, Samoa, as member of Rockefeller Foundation's activities in foreign countries, at times under Dr. Victor Heiser.

*Miller, Janet, *Jungles Preferred*
Houghton Miffln, N. Y., 1931
Experiences of woman doctor in Africa, autobiographical.

Wilson, C. M., *Ambassadors in White*
N. Y., Holt, 1942
Stories of doctors in tropical service for U. S.; Gorgas, Reed, others.

Wood, L. N., *Walter Reed, Doctor in Uniform*
N. Y., Messner, 1942
Biography.

c. Nurses

Dickens, Monica, *One Pair of Feet*
N. Y., Harpers, 1942
Great granddaughter of Charles Dickens decided to become a nurse to help out in this war, in the United States. Lively story, true picture of nurse's training.

Kern, C. J., *I Was a Probationer*
N. Y., Dutton, 1937
Autobiography of nurse's training in large city hospital.

Kern, C. J., *Nursing Through the Years*
N. Y., Dutton, 1939
Continues above, covers experiences as surgical nurse and up to the present.

Nall, T. Otto, *New Occupations for Youth*
N. Y., Association Press, 1938
Interview with public health nurse, pages 177–184.

d. Researchers in Medicine

*De Kruif, Paul, *Hunger Fighters, Men Against Death, Microbe Hunters, Fight for Life, Seven Iron Men*, or any others, . . . all are good biographical material of medical workers, past and present.

Silverman, M. M., *Magic in a Bottle*
N. Y., Macmillan, 1941
Story of researchers in drugs which we use now such as sulfanilamide, quinine, morphine, etc.

Other Occupations Based on the Biological Sciences

a. Entomologist, Government

Howard, L. O., *Fighting the Insects*
N. Y., Macmillan, 1933
Autobiography of famous government entomologist. Probably too detailed and heavy for most high school pupils, but nevertheless gives good idea of training and activities of such a career.

b. Government, Predatory Animal Hunter

Kennedy, Bess, *The Lady and the Lions*
N. Y., Whittlesey House, 1942
Young Texas woman appointed in 1936 as predatory animal

hunter of U. S. Govt., to kill mountain lions and other animals preying on domestic animals.

c. Scientific Research Assistant
   Nall, T. Otto, *New Occupations for Youth*
   N. Y., Association Press, 1938
   Interivew with Gloria Hollister, Dr. W. Beebe's assistant in oceanography, pages 154–161.

THEORY vs. APPLICATIONS

Allen F. Strehler
Ohio State University, Columbus, Ohio

Usefulness and utilitarianism are the watchwords of the hour; teachers are being asked, "Do you teach subject matter that has immediate practical value?" and from all fronts comes the demand, "Give us only material that will solve the problems of the moment."

Teachers of the sciences, whether in high school, college, or graduate school, are not spared the questioning and criticism, and in reply they have two choices: either to justify their courses as they now are set up, or to devote a larger portion of course time to the applications. Let us hope that those who have shifted to the "more practical" have done so only after becoming quite convinced that they no longer can stand on ground which in pre-war years they thought to be most solid!

The statement that in order properly to solve problems growing out of a bit of theory one needs first understand that theory is so obvious as to defy elaboration. Yet its clarification is demanded by statements such as "I can't do these chemistry problems because he gave us too hard ones right away" and "Where did they get these variation formulas?" which fall on our ears from students of several high schools and colleges—from the potential scientists of America.

Needless to say, the problems we give in most science courses under the graduate school level are more simplified than those that arise either in industry or in the military services. If, then, we are to prepare a student for usefulness in his later work, we must give him the best basis possible for expansion of his problem analysis to more complicated situations. Can we give him this basis best by drilling him in problems so simplified and stereotyped as to be almost meaningless or by acquainting him more thoroughly with the theory of the solution? The answer is

obvious: we must see that he is well grounded in theory.

Application of theory to unfamiliar situations is at least conceivable; generalization from familiar to unfamiliar problems is not. Bewildered indeed would be a student of botany who had spent all his time learning the classifications of the common leaves of Ohio were he to find himself in North Africa or in the South Pacific Islands—not only bewildered, but useless! Better would be his preparation for the task had he spent his course hours in learning the general, and indeed theoretical, classification of the leaves of all plants, together with their characteristics.

Furthermore, the reasoning of a student who attacks a hard problem by direct appeal to theory is more likely to be accurate than the empirical reasoning of one versed only in elementary applications. If we were to spend our time teaching only solutions to simple exercises, might we not produce a generation of scientists who double the dimensions of a machine in quest of twice as much work capacity (engineers tell us such has been done in factories of no little repute) and who move their lamps twice as near for twice as much light? Such planning would be wasteful of our time and of our raw materials, and wastefulness of that sort is actively detrimental to the welfare of the nation!

Then, too, if we slide over theory in our haste to arrive at the applications, are we not bypassing the one real opportunity for inspiring students in our field? To hand a student a sheet of ready-made formulas, together with the interpretations of their various symbols, is not to arouse even curiosity, let alone any real zest for research. We may impress him with the practicality of the science as it has been developed thus far; but we provoke no questions in his mind as to how much *more* practical the science would be were it developed further. In neglecting theory we can almost be traitors to our science; and whether we are traitors consciously or unconsciously is apart from the point, for the results can be disastrously the same.

The problem of theory vs. applications seems clear; and yet, because of our inestimable responsibilities to the present and future, we cannot acquaint ourselves too thoroughly with its implications. Such acquaintanceship can be attained in large measure through friendliness and intellectual intercourse both with men in our own field and with men in the other sciences. This much is certain: our very recognition of the problem starts us on the way to its solution.

AN EFFECTIVE LABORATORY METHOD FOR HIGH SCHOOL PHYSICS

Richard D. Spohn, S.J.
Alma College, Alma, California

Today more than ever before, high school science teachers are looking for methods and procedures that will give their students a sound training and will fit them for advanced work in college.

Particularly is this true of high school laboratory methods. Any instructor who is truly sincere must realize that the "cook-book" type of laboratory manual with its completion statements and oversimplified data blanks is a far cry from the exact and thought provoking methods that will later confront the student in college. Furthermore, how often does the use of such a manual promote anything better than guesswork or copying?

As for the plan of turning a spirited group of youngsters loose in the laboratory to devise their own methods and experiments, on the plea that it teaches "the scientific method" . . . experienced teachers know that the laboratory soon degenerates from a proving ground of scientific principles to an adolescent's playground for unrestricted horseplay. The sole exception to this, perhaps, would be a small and expertly directed group.

Some maintain that the student should learn a scientific principle through his own discovery in the laboratory before the matter is treated in the lecture class. Experience, however, seems to show that it is asking too much of a student with little or no background to discover by his own technique what it has taken some of the world's keenest intellects centuries to achieve.

Then, there is the objection that with formal laboratory work the student not only knows the outcome of the experiment befor he begins, but that no initiative or originality is required, and therefore he is given no challenging problem. Yet, students do find many challenging problems in their formal laboratory work. Time and again students after analyzing their mistakes have asked to stay after school to repeat their measurements so as to reduce their percentage of error. Even after performing the regular experiment they may have devised another procedure which they wish to try. Granted the fact that they already know the outcome or the accepted value of some physical constant,

this does not blight their initiative and originality but acts as a stimulus to force them to use the apparatus with intelligence and careful exactitude so as to come as closely as possible to the accepted value.

It is my firm belief that to be effective high school laboratory work should be conducted according to a plan similar to that employed in college. We should demand careful preparation, thoughtful procedure, thoroughness, accuracy and neatness. In this way, our students will receive a good solid foundation, a knowledge of the fundamentals and an appreciation of scientific procedure, whether they are to go on to advanced work or not.

A Physics Class at Bellarmine Prep,
San Jose, Calif.

To achieve this, a method has been drawn up at Bellarmine Preparatory during the past two years, and used with gratifying results. Instructions on how to prepare and perform laboratory experiments were mimeographed and given to the students. They are reproduced here in the form in which they were given to the students. The notes contained first of all a definite objective:

The purpose of laboratory work in a high school physics course is to gain an appreciation of scientific procedure, the importance of minute details in the accurate tabulation and inter-

pretation of experimental data and a facility in using simple instruments in verifying the various laws of physics.

Part I: Preparation

"A research problem is not solved by apparatus, it is solved in a man's head. . . . The laboratory is the means by which it is possible to do the solving after the man has the idea clarified in mind." Charles F. Kettering, Director of Research, General Motors Corporation.

A. At least one half hour should be devoted to a careful study of the experiment manual and the corresponding material in the text book.

Note the procedure of the experiment, the steps taken, their purpose and their order. Study the plan of the apparatus, the manner of using it and the purpose of each adjustment.

Do not consider the experiment prepared until you can answer the following questions definitely:

1. What is the object of this particular experiment? i.e., what law or principle is to be tested or verified?
2. How is this to be done? what procedure is to be followed?
3. What apparatus is to be used?
4. What sources of error in this particular experiment are to be avoided?
5. Where is the subject matter of this experiment treated in the text book in case I need to refer to it in the laboratory?

B. Answer these questions briefly but adequately in ink. Hand them in at the start of the laboratory period as an outline of the experiment. Add to this a list of the books you have consulted and the pages studied in preparation for the experiment. N.B. Failure to do this outline automatically limits your mark for the experiment to a passing grade.

Two laboratory periods a week are given you for an experiment, normally on Tuesday and Thursday. Thus, you will have ample time to complete your work thoroughly.

Comment on the Preparation

The purpose of this outline is to have the student make a thoughtful analysis of the experiment before setting foot in the laboratory.

Of course, the student can copy someone else's outline; but this manifests itself almost immediately in the laboratory, either by his inactivity, or by the questions he will ask the instructor.

That is why the outlines are turned in at the start of the laboratory period and not returned.

Even though a quantitatively fewer number of experiments are worked during the year in this method, it has seemed more efficient to have a student work twenty experiments thoroughly, rather than forty haphazardly. Another advantage of working the experiment through two laboratory periods is that it gives the student opportunity to clear up difficulties in his working of each experiment.

For the more adept student there is always an assignment of questions and problems from the text book, and for additional credit. As repetition is the mother of learning, it does not matter if they have worked these questions and problems in some prior homework assignment.

Part II: Procedure in the Laboratory

1. Bring your textbook and manual to the laboratory.
2. Unless otherwise directed by the instructor, you and your partner will always work at the same table. The number of this table with your name and that of your partner is to be written at the top of your individual laboratory reports. Clip the reports together before handing them in.
3. Each table is completely equipped and it is unnecessary to remove apparatus from other tables, or to wander about. If you need anything, ask the instructor for it.
4. All observations and readings should be recorded just as you see them, and not as you think they ought to be.
5. In your measurements and calculations, use significant figures as explained in your textbook on pages 13 and 14 (Millikan, Gale and Coyle).
6. Percentage of error is calculated by dividing the amount of the error by the true value of the quantity measured, and then multiplying the result by one hundred.
7. Leave all apparatus in perfect order and replace the stools under the tables.

NOTE: You are graded not only upon the preparation, precision and neatness of your outline and report, but also upon your conduct during the experiment.

Where this method is followed, students are quick to grasp the value of careful preparation and procedure. They also learn to analyze and solve their own difficulties, and become less and less dependent upon the laboratory instructor.

No trouble has been encountered in establishing this method in either large or small classes, after the plan has been explained to them. This is particularly true when the instructor lowers the mark of the student five or ten points for any part of the instructions he neglects.

The method has been used at Bellarmine Preparatory with as many as forty students in a class; it has proved so practical that it has been adopted by several public and private schools in California. The manual in use has been Millikan, Gale and Davis, *Exercises in Laboratory Physics.*

Like all methods, it has its defects: but it comes closer, I believe, to the ideal of teaching science than merely to teach about science.

APPARENT SPEED OF A MOVING OBJECT SEEN THROUGH A FIELD GLASS

Conrad K. Rizer
College of the City of New York, New York

Note. Dr. Cecil E. Reynolds, M.D. of Glendale, California, asked the Journal of the American Medical Association (Jour. or July 8, 1939, p. 167) why an automobile moving towards him seemed to move so much slower when seen through a field glass than when seen with only the eyes. The treatment given in the Journal was correct for head on motion but was misleading for motions seen at an angle other than zero with the line of sight.

An observer stands in the middle of a highway traffic lane, not a recommended procedure, and watches through a field glass of x magnifying power a car coming towards him at a rate of v miles per hour. The glass will make the apparent speed of the car to be v/x because in the equation

$$\text{Distance} = \text{Speed} \times \text{Time}$$

the time is independent of how the car is observed. However, the apparent distance and speed are $1/x$th of their value without the glass. Thus a ten-power glass will reduce the apparent speed 1/10th.

If now our observer steps a safe distance away from the road and watches the oncoming car through the glass, he will notice the speed increases till the car is directly opposite him, the motion of the car being at right angles to his line of sight. In this position the car's apparent speed is x times v because the appar-

ent distance the car moves in a unit of time is x times the real. Corresponding real and apparent distances are traveled in the same time in this case as in the first.

To find the apparent speed Q of the car when the line of sight of the observer makes an angle A with the line of travel of the car, the following equation may be used

$$Q=\frac{v}{x}\cos^2 A+vx\sin^2 A.$$

The reason for the two terms on the right side of the equation is because Q is the resultant of two components, one along the line of sight expressed by $\frac{v}{x}\cos A$, the other at right angles expressed by $vx \sin A$. The first term has little influence on the value of Q except for angles close to zero. The equation virtually has a sine^2 curve, v and x being considered as constants. There is an angle A where Q equals v making it possible to remove them from the equation for this condition. The effect of x on angle A may then be noted.

Thus moving objects seen through a magnifying system such as a field glass seem to vary more in speed than when seen without such aid.

DOCTORS URGED TO WATCH FOR JAUNDICE MONTHS AFTER BLOOD TRANSFUSIONS

Doctors should be on the lookout for jaundice developing one to three months after blood or plasma transfusions, Dr. Paul B. Beeson, of Grady Hospital and Emory University School of Medicine, urges in a report in the Journal of the American Medical Association.

Dr. Grady reports seven such cases in which he believes the jaundice was probably caused by some substance in the blood or plasma used for transfusions. The condition is similar to cases of jaundice that have been reported following yellow fever vaccinations and use of convalescent serum in measles and mumps.

More such cases may be occurring without being recognized, Dr. Beeson suggests, because the long period between the transfusion and development of jaundice may mask the significance of the transfusion in causing the condition.

The only way to find whether jaundice is frequently occurring as a result of blood and plasma transfusions, Dr. Beeson states, is for physicians to make a concerted effort to recognize such cases. He suggests the following two practical measures for investigating the problem:

"First, a careful record should be kept of the source of blood or plasma administered to each patient. Second, a small portion of blood or plasma should be set aside at the time a transfusion is given, so that, in the event of subsequent cases of hepatitis, some of the causative material will be available for study."

ELEMENTARY SCIENCE MEETS THE AIR AGE

Edward P. Powers
Ocean Avenue School, Northport, New York

[Editor's note. The article that follows explains how one of our resourceful elementary science teachers is meeting the challenge of the air age in his classroom. Unfortunately space does not permit the publication of the entire unit. However, Mr. Powers advised us that he will be willing to send a copy of the complete unit to any teacher who includes a self-addressed and stamped envelope with his request.]

Today the schools of America are faced with a challenge that never before has been equalled in our short but glorious history. An old era has passed to give way to the swift moving world of the present and the future. It is a human impulse to resist change and the changes and innovations of the future are beginning to reach vast proportions. It is time to recognize these changes, accept them and rise to great heights with them.

The age that is passing will some day seem moderate to us. A complete and revolutionary change is occurring in our great transportation systems and in our way of living. No longer in moving from place to place over the globe are we obstructed by icebergs, mountain ranges, deserts, ocean currents and vast, uninhabitable areas. Modern aviation has conquered many of the geographical obstacles to man's globe trotting. He has built wings of such proportions that he can swiftly erect the highways of the sky and travel upon them to business, to pleasure, and for the movement of his goods.

Man is pioneering in a new kind of trade routes,—routes that made the globe shrink; routes that we hope will knit all mankind into closer understanding and friendship; routes that will destroy international animosities and bring civilization to lasting peace and economic security.

Though the airplane is being used to destroy, it can be even more vital in peacetime than it is now during wartime. So the challenge is clear. Science, social studies and mathematics must be brought into co-ordination with the fundamental principles of this new age.

How can this air-mindedness be developed in the elementary schools? The answer is to plan units and activities around centers of interest dealing with aviation. We are trying to develop a program of this kind described along the lines that follow.

That children are naturally interested in airplanes goes without question. On our playground they constantly point to the

planes in flight and name the various types with ease. There is a large army base near our school and several aircraft plants. Many of the children's parents work in these plants and the children's knowledge of aviation is astounding.

One day in class the discussion led to the subject of planes after a large bomber roared over the school building. Some of the children wanted to bring in pictures they had collected to show to the class. When this was done, others brought in model planes on which they had been working. Some one suggested that it would be fun if they would build model planes in class. The suggestion was enthusiastically received. The next day, equipped with plans, razor blades, glue, pins and parts, the children set to work busily upon their models. As the contruction progressed I found myself surprised at the accuracy of the children in handling details. It was necessary to consult books on airplane construction.

In building the planes they asked many questions about plane parts, and from these questions we all learned much about the structure of planes. When completed we had an exhibit of our handiwork. Some added a realistic touch by hanging their planes from a light fixture so that they could sit in class under the magical spell that a plane creates in children.

After completion of the planes the children wanted to know how and why planes dive and climb. To answer these questions we engaged in some simple aeronautics. For rudder operation we attached a small cardboard rudder on an index card and pinned the card to a cork that extended above the neck of a bottle. We discovered that when we blew on the rudder the whole card would turn. Thus we discovered that the rudder's purpose was to turn the plane. Investigation of diagrams revealed that the foot pedals operated the rudder.

One boy inquired about the flaps on the tail of his plane. To investigate this problem we rigged up another experiment with a small cardboard plane with lowered flaps. When we blew on the flaps the tail of the plane rose. When we raised them and blew on them the tail lowered. Suddenly, a girl exclaimed "Now, I know! When the pilot lowers the flaps on the back he goes into a dive, and when he raises them, he climbs." The mystery was beginning to unravel, and someone was assigned to find out what made the flaps move.

The question arose as to how a plane banked. One boy volunteered the information that the front wing flaps must have

something to do with it. After some deliberation solutions came to light. They reasoned that if the flaps were up the wings would be pushed up or down. We did some experiments and found that they did not operate in the same direction at the same time. On a small model plane we lowered and raised one wing flap. Tying a string to the nose we pulled it up and the plane banked in one direction. Demonstrations with a larger plane confirmed our conclusions as to the actual function of the wing flaps.

Understanding the purpose of the stabilizer was the next step. We found that our model plane, without a stabilizer would not fly, because there was not a flat surface on the tail to hold it up. We were fortunate one day to have a child bring a model plane, complete with instruments and controls that readily demonstrated all the points that we had covered. Then the children took a "pilot training test," in which they told how to dive, climb, bank, take off and land.

But why do these planes fly? Charts were made of the parts of planes. Kites were brought to school and flown above the playground. From this we discovered interesting things about the action of air on a surface. We constructed a wind tunnel with an electric fan, fastened a small plane to a stand, soaked a little turpentine on cotton, attached to a long stick, set the cotton afire, and followed the wind currents on the wing with the smoke. We found that the smoke pushed against the lower part of the wing, and that there was not so much smoke immediately above the wing. The fan was our propeller. We then did experiments with air pressure which can be found in most elementary science textbooks. This helped create a greater understanding of high and low pressures on the wing.

Along with these experiments we built some toys that helped show the action of air. We made toy helicopters, autogyros, parachutes, airplane wind vanes, paper gliders, and other devices. All these helped to develop simple principles of Aeronautics.

The unit developed from one stage to the next. To attempt to go into detail would involve many pages. The unit grew in this fashion and before completion covered a surprising area and developed some interesting and useful concepts.

In addition to the problem previously mentioned an interest was expressed in the instruments which pilots use. We made a list of the instruments needed and then checked it by research.

The next step was to discover how some of these instruments functioned. We experimented with the compass and saw that this instrument showed us direction but we didn't know why. After magnetizing some needles we put them in corks and made boats that would point to the north. We suspended bar magnets and found that the North-seeking pole pointed north and, we then disturbed the compass needle by putting it near a wire that had a current in it. After various experiments of this nature and more research, the children readily saw both the need and the function of a compass. The next step was the altimeter. We made a mercurial barometer and checked it each day. The various gauges such as the tachometer, oil-pressure gauges, and gas gauges were subjects of reports by the children along with an up-to-date report about the radio beam.

From this point on the children began asking questions about blind flying. This immediately swung us into the phase of weather and its relation to the pilot. We learned to read barometers, make thermometers, build wind vanes and to study clouds. Anemometers were constructed and we reported on visibility, ceiling, soup, fog, hail and snow. At this point they were ready to make a weather station and predict the weather for the safety of their imaginary pilots. This we did, but in order to make it more realistic we built a model airport complete with control towers, parking spaces, runways, hangars, searchlights, repair shops and wind socks.

This project in co-ordination with our weather project enabled us to understand the control of traffic in the air and many of the areas of science which surround a pilot and protect him before he takes to the air. We made imaginary flights with our weathermen supplying data to airport officials, this in turn being relayed to the pilot. The children found this very exciting but from it, they derived much valuable information and ideas. For instance, the science of meteorology is an important phase of aviation, aviation is dependent upon many branches of science, and the behavior of winds, air currents and other factors that make up the weather, are but a few of the related fields of study. Most of all they learned that men must cooperate for their protection, welfare, and progress.

At this point some one suggested that it would be nice if we could visit an airport or an airplane plant where their parents worked. This being out of the question in wartime, we did some improvising and built our own aircraft plant. Many reported

to the class information on aircraft production supplied from their parents. We collected pictures of aircraft plants and studied them. We were fortunate in securing samples of airplane materials, such as aluminum, glass, duraluminum, steel, wire cables and fabrics. These we studied and tested for weight and durability.

Not knowing the original source of these materials, one group volunteered to find out how we procured these metals. As a culmination to their work, they built model mines and steel blasting furnaces, and reported to the class. With this information as a guide we simulated a plant, bought some model planes of the same type and arranged the children in rows. Down the "assembly line" they worked on certain sections of the models and in a surprisingly short time we were turning out planes. This told the whole story easily and pleasantly.

One of the incorrigibles helped us solve our next problem, or, at least, he suggested it. During the lesson he had blown up a balloon and was attempting to make it float in the air. A new area to be covered, therefore, appeared. Queried as to why balloons did not float, the children offered various opinions—all indefinite. Assigned the problem they did some research and found that they needed to so some work on floating objects to help prove this. Armed with battery jars, corks, and various other materials we floated objects and discovered that they had to be lighter than their supporting substance. We filled some balloons with hot air and saw them rise. Next we generated some hydrogen gas and actually floated some balloons in the room. During their research they discovered that balloons were the first objects that man used to reach into the unconquered spaces of the air. This led to further study of this phase and through it we traced the development of the airplane from early times to the present. We topped this off with a frieze showing the development of aviation.

Brought to the present, we discussed the future of aviation. They offered all kinds of predictions as to the type of the airplane to be used in the future. Some children brought in pictures of ultra-modern devices that were meant to span the skies.

Altogether, it proved to be a fascinating unit, one that grew in proportion as we went deeper into our study. Many areas of science entered in. More than that, it tended to give the children the following concepts:

1. Air maps give us a new phase picture of distance.

2. New industry of vast proportions is being developed and that someday most of us will play a part in it.
3. Great pioneers have made aviation what it is today.
4. Aviation depends on much scientific knowledge for its success.

NOTES FROM A MATHEMATICS CLASSROOM

Joseph A. Nyberg
Hyde Park High School, Chicago, Illinois

(Continued from the May issue)

49. The Area of a Rhombus. In item 25, October 1942, I mentioned that certain geometric exercises are significant because they teach something more than a single geometric fact. Such an exercise is the following:

The area of a rhombus is half the product of the diagonals.

We can start the proof by saying that the area equals the base times the altitude, and then by using similar triangles we can change this product to the desired product.

But the area of any parallelogram is not half the product of its diagonals; hence there must be something in the above proof which will not hold if we are dealing with a parallelogram that is not a rhombus. We examine the proof step by step to find the significant one. After finding that the crucial step is the perpendicularity of the diagonals, we ask: Is it then necessary that the figure be a rhombus? Perhaps all that we want is a quadrilateral with perpendicular diagonals. We thus have an opportunity to discuss what is meant by *necessary and sufficient* conditions in an hypothesis. Being a rhombus is sufficient but not necessary.

The exercise may also be proved by considering the rhombus as the sum of its triangles. We may write the area of each triangle and add, or double the area of one of the triangles, or quadruple the area of one of the smallest triangles. Also, in finding the area of one of these triangles, which line shall be the base? A sensible choice will make the work easier; a foolish choice does not prevent us from reaching our goal but will make us work longer. All the methods will work. We may draw a moral: "Sometimes it doesn't make any great difference on how you start a task. You can succeed if you are willing to stick to the task and are not easily discouraged."

But we have not exhausted the possibilities of this exercise. To double the expression $\frac{1}{2}\ AC \times BE$ do you get $1 \times 2AC \times BE$ or just $AC \times BE$; and, if so, why?

If you are adding some of the triangles, what is the sum of $\frac{1}{2}\ AC \times BE$ and $\frac{1}{2}\ AC \times ED$? If these expressions are written one below the other, as they would be in a proof, some pupil get the sum: $1 \times 2\ AC \times (BE+ED)$. And so the exercise offers a chance to review some facts about adding products.

50. The Metric System and Pre-Induction Classes. Last fall the superintendent ruled that a course in Mathematics and Physics of Aviation (for which two years of mathematics was a pre-requisite) would be required from all boys. (The rule was changed this spring and the course is now elective.) I am teaching one of the classes this semester. Except for three boys, out of 25, there is little likelihood, on the basis of their previous record, that these boys will ever become aviators. Further, they are not interested in aviation and are sure that the war will be finished before they ever see a training camp. But a requirement for graduation is a requirement for graduation.

Early in the course we studied the metric system and the use of significant figures in measurements. We aimed to consider only such problems as might confront a private, not a pilot, nor an airplane designer, nor a trained mechanic. At the end of the unit I gave the test shown below. In answer to the question "To how many significant figures should each answer be found?" I said, "To as many figures as you think the problem demands. This is a test of your common sense as well as a test on metric units. Further, please consider the practicality of your answers. A soldier does not carry $2\frac{1}{2}$ rifles or wear 3 pair of shoes at once."

1. If a driver wanted 200 gal. of gas, how many liters should he ask for? Ans. 750. Although 200 gal. equal 757 liters, it is unlikely that a man would ask for such a number, and it is doubtful if he would ask for 760.

2. The enemy's target is 18 km. away. How many yards is that? Ans. 20,000 although 18 km. equals 19,800 yds.

3. A shell weighs 25 kgm. A truck can haul 3 tons. How many shells can it haul? Ans. 110. Although 25 kgm. equal 109 shells an extra shell will not ruin a truck. Hence either 100 or 110 is a satisfactory answer.

4. A platoon marched 8 km. in an hour. At that rate how many miles would it cover in 10 min.? Ans. About a mile, although $\frac{5}{6}$ mi. is more exact.

5. One soldier carried 40 lb. on a long march on a hot day. Another carried 18 kgm. How many more pounds did one carry than the other. Ans. A trifle, not worth mentioning, since the difference is only .31 lb.

6. How would a speed limit of 35 mph. be stated in Paris? Ans. 55 meters per hour although the equivalent is 56.3.

7. One aviator reached a height of 12,500 m. Another reached 40,300 ft. What is the difference in feet? Ans. 710.

8. A sergeant estimated the width of a river to be 300 yds.; the true width was 280 m. What was the per cent of error? Ans. About 2%.

9. A hole 12 m. by 6 m. by 2 m. was dug for a tank trap. How many cubic yards of dirt were removed? Ans. 185, but 180, 190, or 200 are considered satisfactory answers.

10. A cylindric gasoline container is 3 ft. long and 20 in. in diameter. How many liters of gas does it hold? Ans. 188, but 190 or 200 are considered better answers.

Paper and pencil are not part of a private's equipment. Hence on a later test the pupils were required to solve mentally similar but simpler problems. The object was to train them to estimate rapidly. I read the question, and the pupil was required to write an answer within ten seconds. Sample problems were: 15 km. is how many miles? 20 liters is how many quarts? What is the per cent of error in using 50 yd. for 50 m.?

51. A Foolish Problem. The verbal problems of algebra have often been criticized, and I have often written in their defense. But the following problem seems ridiculous:

Find two numbers whose sum is 9 and whose product is 20.

To guess the answer would be against the rules of the game. The pupil is expected to write $x+y=9$, $xy=20$, or, if he uses only one variable, $x(9-x)=20$.

In either case the pupil gets $x^2-9x+20=0$, and is then expected to solve this equation by factoring. To do so, he must guess two numbers whose product is 20 and whose sum is 9. But this is the very thing he was not allowed to do a few minutes ago. Either the problem should require that the equation be solved by the formula or some other method than factoring, or we must justify the problem in some other way.

52. Factoring ax^2+bx+c. Courses in algebra usually include the factoring of x^2+bx+c, but many courses state that the factoring of ax^2+bx+c is optional. Is it omitted from minimum

courses because it is supposed to be more difficult or less important?

After a day or two of factoring quantities like $x^2-9x+20$ the pupil forgets that he is dealing with products of binomials. He looks at 9 and at 20, and thinks "Find two numbers whose sum is 9 and whose product is 20. Write one of the numbers in each parenthesis." The pupils even ask for rules like: If the signs are $-$ and $+$, make 'em both $-$; if the signs are $++$, make 'em both $+$; and so forth. Mechanically he scribbles numbers in the parentheses, and thinks of something else.

Twenty years ago I thought that factoring the x^2+bx+c was a necessary prelude to factoring ax^2+bx+c, but now I begin with the general case and never say anything about the quantities in which $a=1$. After treating the general case, the special cases, even x^2-c^2, take care of themselves and need no separate treatment. I have had many classes in which the IQ's were mostly in the nineties but they all learned to factor ax^2+bx+c. And because they were compelled to deal with four numbers in place of just two, they were less likely to forget that they were dealing with products of binomials. Even if the type x^2+bx+c were sufficient for their needs, I would still begin with ax^2+bx+c to promote a better understanding of multiplication and factoring.

53. For the Class in Pedagogy. If y is proportional to x, then $y=kx$, and we think of a table of corresponding values in which there may be any number of x's and y's. Likewise, if y is inversely proportional to x, or if y varies as the square of x, and so forth, we have a collection of y's and a collection of x's. But when two triangles are similar, we have at most three sides in each triangle; and if two rectangles are similar, we have a proportion involving two lengths and two widths. Where, in these problems, do you get a collection of lengths and widths, or a collection of sides?

The question is not stated exactly as pupils have asked it, but I have expressed their confusion. The problem for the class in pedagogy is: How do you answer the pupil in a geometry class? Can you answer it in two minutes or less? Does the question deserve more time? Should the question be anticipated, and the treatment of proportions be different from the start?

Correction. In the problem on page 267, March 1943, the value of f should be 0.00900.

HOW TO STRENGTHEN THE TEACHING OF HIGH SCHOOL BIOLOGY

HELEN TROWBRIDGE
Glenbard Township High School, Glen Ellyn, Ill.

It is impossible for the teacher of biology to be an authority in every phase of biology. However, it is the business of the teacher of this subject to be so well versed that he can meet the challenge which he encounters when he meets his students. Some of these students will be well read and will have had opportunities and experiences to give them valuable knowledge and an abundance of enthusiasm in this field. The teacher must be able to stimulate this interest by giving to the individuals under his direction an ever increasing appreciation and practical knowledge in this subject.

The question arises—How can the teacher strengthen and vitalize biology? After a number of years experience in teaching only biology a teacher cannot fail to be aware of the fact that he is working with persons who possess individual differences, and therefore, each student must be regarded as a distinct personality. But neither can the teacher chart a specific course for each student who comes to him for instruction. So this requires a deftness on the part of teachers to keep a whole group interested. To keep up this interest for the whole group no teacher should attempt to follow an outline from year to year. He becomes stale, for stereotyped work has no interest for either teacher or student. Teach the biology material that is in the child's immediate environment, for with a knowledge of this subject matter, the child will have an understanding of his own surroundings and he will be able to increase his biological knowledge when he increases his experiences through travel, reading, increased class work or research. The basic principles remain the same regardless of the location. High school students are interested in factual material and not in theories. With the abundance of factual material the child's biological interest can be intensified with the right guidance. We are all interested in ourselves—so is the child. The biology classroom is the natural setting to teach the child about himself. True enough we will have to do this piece-meal, but, let us never fail as we go along to keep the completed picture in front of the student.

In helping the child to know more about himself we should help him to understand how growth and development take place

from the time of conception until maturity; the kinds of foods essential in the diet and the function of each of these foods for proper bodily functioning. This material should be up-to-date and presented in a manner that will impress the child with the facts of how he can help himself. Material based on reason is effective. Food study gives the teacher a marvelous opportunity to connect up various systems of the body. The digestive system —for food must be ingested and digested to be of value to the body; soluble food must be transported which brings us to the circulatory system. Give the student a well rounded out knowledge of the blood and its composition, value to the system as a whole, parts of the body that enter in this picture to keep the blood in a healthy state. Explain the heart, blood vessels, and lymphatic system thoroughly to the child. The blood cannot get its oxygen supply without it is supplied by the respiratory system. Help the child to realize the various protective structures present in the body to help him ward off diseases and infections. When food is taken into the body there will be a certain per cent of waste. This gives the teacher an opportunity to stress how wastes are eliminated or utilized by the body. Even with all of these systems performing naturally still the endocrine system must be in harmony or else there will be bodily disturbances of one kind or another. The student needs guidance in regard to food advertisements, so that he will be able to see the "within-the-law" advertising, and the "catch words" used to impress certain products on the market for increased sales. Appeal to the child's finer judgment in the use of harmful drugs on his body, as well as, his responsibility to other people. "We are our brother's keeper."

Give the student an increased knowledge about his nervous system. Just and intelligent discipline is essential for man to develop responsibility and self-control. Man's goal should be to exercise self-control, but even though man may never accomplish it—it still should be his goal. Help the child to better understand how his nervous system is the MASTER, yet for unification there must be the proper functioning of all systems. Lead him in his thought to realize that what he may accomplish for himself is due to a high degree to himself. He inherits equipment but he must develop this equipment. Man's greatest inheritance is his cerebrum (an organ of associative memory and the structural foundation of human culture), the quality which makes man able to guide, within limits, his own destiny. Stress

here that education should be a "voluntary process of self-development and self-dependence rather than one of external pressure and compulsion." This unit well developed is fascinating to the child.

Give the child a workable knowledge of genetics and eugenics. Make him realize the great possibilities made possible through inherited characters. What child will not give more thought to his marriage when he realizes that there is a chance for over seventeen million characters to be transmitted by one couple to their offspring? This unit gives the teacher an opportunity to help the student to take a saner viewpoint in regard to desirable and undesirable human characteristics; that "love should not be blind"; and that the student should train himself to measure-up to the responsibilities of parenthood.

The reproductive phase has a definite place in the biology course. Here it is possible to emphasize and explain venereal diseases. The high school child appreciates facts—facts should be given here and actual figures in respect to his own state. Reasons for physical examinations before marriage and his duty to live up to these laws should be explained. The value of prenatal examinations by competent doctors should be stressed for his own health, as well as for the protection of his offspring. Impress upon the student that congenital handicaps can be prevented if the mother has regular examinations the first five months of pregnancy, particularly, the first three months. Biology is the natural setting, and if the teacher has the right viewpoint and attitude he can do a wonderful work right in his classroom to help boys and girls. Make these boys and girls realize that they are our only missionaries in this field and that they can do no greater service to humanity than to help spread the true facts in regard to these social diseases.

Know how biology figures in today's war program and give the child an understanding of the importance and delight of the subject, an inkling of the scientific method, a beginning of a biological outlook, and a respect for living things. In some this will later develop into a study of specific science; in others a naturalist's enthusiasm; in others a more understanding approach to general reading and contact with a wider philosophy of life.

The best way to vitalize biology is for the teacher to "throw away" one textbook and teach biology from nature, from books by authoritative scientists, recent publications from all pos-

sible reliable sources, from lectures by authorities in particular fields, through visual aids, and recent knowledge gained by going to school. Be a teacher who makes your students appreciate you are their director because of your experience over theirs (due to years not brains). Impress the facts that no one ever completes his education in the field of biology, even though he lives a normal span of life. That that is an inspiration, for even with the knowledge that is known, there is more to learn than has been found out thus far. Be a teacher who has initiative and one who does not follow a routine method in either teaching or tests. Each year have the subject meet the needs of the present time. This keeps the teacher from getting in a rut and this increases the interest in biology for students. Be the teacher who exercises common sense, considers and is governed by the actual environmental situation to get effectual biology across to the students because he has made a constructively critical evaluation of both matter and the method for teaching it. Be impulsively enthusiastic about your subject and your students will appreciate that you are in a field that you yourself really enjoy, believe in, and are in love with. Students of such a teacher will, in spite of themselves, enjoy biology and realize the practical importance of such a subject in every day living.

In conclusion the aims of a biology course should be: (1) To reveal—to open the eyes and ears of our students to the wonders of their environment. "If you look, you see." (2) To develop understanding through increased knowledge through scientific discovery that has been made and should be made. (3) To form habits, abilities, skills and to develop functional knowledge of science that will aid people to better cope with their environment with its complex problems. (4) To instill the pattern of scientific thinking into well disciplined minds and to direct the application of this thinking into every area of human endeavor. (5) To teach the lessons of nature's discipline as a basis for democratic discipline—the respect for authority for better citizenship and a more worthwhile individual to society. Discipline is essential all through man's life. (6) To create new ideas, impress students with the importance of initiative to develop new products, new inventions and thus create new jobs as a basis for continuing the democratic way of life. (7) To contribute to the general welfare of all free men, a positive, wholesome, constructive, and abundant life for all.

STREAMLINING GENERAL SCIENCE FOR AN AIR-MINDED GENERATION

Standish Deake
The Park School for Boys, Indianapolis, Indiana

"General Engineering" might be a more appropriate name for the course in general science outlined in this paper. This course is an attempt to capitalize on the fact that nearly every boy enters the classroom or laboratory to the accompaniment of zooming motions of his hands and sound effects reminiscent of dive-bombers. To him, "science" is either airplanes or explosions. The choice between these two motivations admits of little question.

Probably no instructor teaches his general science course in the same way two years in succession. It is too fertile a field for experimentation. Classes vary; so do the instructors' hopes and fears. The end of each school year brings the hope that this year he really did do a better job than he did the last year. Fearfully, he interrogates the students, has them fill out questionnaires and then tries to appriase his work dispassionately. In spite of the author's best efforts he has had two criticisms turn up with shattering regularity. The gist of them is:

1. "The trouble with general science is that such a wide variety of subject matter is taught. It seems as though we hopped around all the time. We never had enough about any one subject."

2. "We'd like more of the type of laboratory experiment in which we actually test something as in a real life laboratory; in which we arrive at a definite result rather than merely demonstrate the truth of a principle for which we are quite willing to accept your word or that of the text."

To the author both of these criticisms of the traditional general science course appear justified. He recalls no burning desire, for example, for a proof of the formula for the area of a triangle. If, when applied, it gave a reasonable result he was quite willing to accept it on pragmatic grounds. In the ninth grade we are trying to inspire the students rather than to impose upon them a rigid scientific discipline. For some students the general science course will be terminal in one or more of the fields covered.

The progress of the experiment to be described in this paper leads the author to hope that he may be on the trail of a method of increasing the terminal value of the general science course,

without sacrificing its value as a foundation for those who go on to the special sciences, and at the same time of overcoming to some extent the recurrent student criticisms mentioned above. These criticisms must be met, not by altering the content of the course, but rather by altering its presentation.

A General Science Course Built Entirely Around the Airplane

For better or for worse, nearly the whole content of the general science course can be organized around the structure, flight, and navigation of an airplane. Much of the laboratory work can be organized around the building and testing of trusses, wings, and shock absorbers, the use of pulleys, chain gears, and belts, the oxidation of fuels, the cooling of engines, transmission of pressures, etc. Part of the laboratory work can be made competitive, e.g., who built the lightest and strongest truss for one kind of stress or another? The necessary calculations appall the students unless thay are made under these circumstances.

Organization of material.—The units of the traditional general science course can be conveniently regrouped under units based on the airplane as follows: The author makes no pretense that this is the best possible organization, but merely that it has worked satisfactorily to date.

Unit one—Fundamental.—A fairly exhaustive treatment of the molecular theory, the three states of matter, and the colloidal state. The elements and combinations of atoms into ordinary-sized, large and giant molecules. Density and specific gravity of structural materials; mass and weight.

In the left hand columns below are shown the units as dealing specifically with airplanes and in the right hand columns the units of the traditional general science course covered in this connection.

Specific Aeronautical Topics	Usual General Science Topics
Unit II, Materials Used in Airplane Construction	
1. Historic use of wood, cloth, and glue	1. Adhesion and cohesion
2. Aluminum, copper, iron, and magnesium	2. Density, ductility, melting point, cast vs. wrought iron, metallic fatigue
Unit III, Stresses	
1. Tensile, compression, torsion, shear and bending stresses	1. Hooke's laws, elastic limit, deformation under prolonged stress metallic fatigue

Unit IV, Trusses

1. External vs. internal wing bracing, I-Beams, columns, punched beams	1. Principle of levers, moments, fulcrum work

Unit V, Fusilage

1. Use of trusses	1. Measurement of bending, tensile
2. Monocoque	2. Strength, etc.

Unit VI, Airfoils

1. Non-lifting airfoils and lifting airfoils, wings	1. Venturi tube, Bernoulli, eddy currents, making and reading graphs, atmospheric pressure, using vacuum pumps.

Unit VII, Landing Gear

1. Springs	1. Review electricity
2. Oleo-gear	2. Fluid pressures, buoyance, force, impulse, momentum
3. Hydroplanes	

Unit VIII, Level Flight

1. Center of pressure on airfoil, lift and drag components of resultant pressure	1. Composition and resolution of forces graphically

Unit IX, Climbing and Diving

1. Positive and negative angles of attact, shift in center of pressure, stalling angle, slots, etc.	1. Laboratory work on wind tunnel models of wing sections made by the students

Unit X, Use of Wing Tabs

1. Construction and control	1. Center of gravity and stability

Unit XI, Effects of Altitude

1. Rate of climbs, ceilings	1. Extent and nature of atmosphere, changes in air density
2. Formula,[1] $L=C_L\frac{DS}{2}V^2$	2. Concept of power

Unit XII, Propellers

1. Considered as collection of airfoil elements	1. Composition and resolution of forces, power, and electricity
2. Torque and thrust	
3. Speed, pitch, and air density	
4. Variable pitch propellers	

Unit XIII, Parachute Descents

1. Materials in constructing a parachute and how it works	1. Principles of force, weight, and pressure

Unit XIV, Engines

1. Internal combustion cycles	1. Expansion of gases, steam engine valves, boilers, power, Carnot cycle

[1] The lift formula is from *Science of Pre-Flight Aeronautics* by the Aviation Research Group, published by the Macmillan Company, 1942, page 230.

2. Cooling by air and liquid	2. Heat and temperature, expansion of metals, calorimetry, abnormal behavior of water, antifreeze solutions, effect of pressure on boiling point
3. Carburetion	3. Liquid pressure heads, vacuum, oxidation of fuels, explosive fuels, superchargers
4. Ignition	4. Electricity, AC and DC

Unit XV, Weather

1. Temperature and pressure variation	1. Winds and wind belts
2. Relative humidity	2. Relative humidity
3. Fogs, rain, frost, ice	3. Review barometers, forecasting, weather
4. Fronts, cyclones	4. Weather
5. Maps	5. Weather maps

Unit XVI, Navigation

1. Latitude and longitude	1. Latitude and longitude
2. Great circle courses	2. Ocean transportation
3. Time measurement	3. Time belts
4. Projections used in map-making	4. Review of mechanical drawing
5. Dead reckoning, traverse sailing, interception problems, magnetic compass	5. Magnetism
6. Use of stars	6. Astronomy
7. Sound signalling, telephone	7. Communication topics

Unit XVII

1. Light, color, and vision	1. Light, color, and vision

Unit XVIII, The Pilot

Almost all of the usual physiological material from the standpoint of physical fitness, service standards, etc.

Unit XIX, Peacetime Uses

1. Exploration	1. Rescue
2. Conservation	2. Experimentation
3. Passenger, express, and mail service	3. Meteorology

It will be noted that much of the material is arranged similar to the way it appears in *Science of Pre-Flight Aeronautics for High Schools*, and may be used as it stands by shifting the emphasis and treatment for use at a night-grade level. A procedure such as suggested above may be followed by using any standard general science textbook. The students are encouraged to think of the textbook as a source of reference material to be used in classroom discussion.

The fact that the specific material on aeronautics is not to be found in the General Science Textbook permits of a "pain-

less" introduction to a modified lecture system, a valuable experience in itself. Copies of the *Air Education Series* may be made available for student reference. The clipping of newspaper items can be made the source of much stimulating and interesting material for class discussion.

The laboratory possibilities are limited only by the instructor's ingenuity and the time available to him. It has been the author's experience that many students are delighted to work extra time in the laboratory preparing materials.

Conclusion

The ninth-grader is apt to be left cold by an exposition of the crystalline and colloidal states and solid solutions which a year or two later would fascinate him. Presented as reasons for the failure of structural parts of airplanes he "eats it up." The greater strength of a material under shear stress than under a bending moment becomes vitally important to him when it explains the method of attaching wings to fusilage. He loves to build airplane models, but has too much homework. Let him build a model wing section as homework and devise a wind tunnel in the laboratory in which to test it. Then he goes home to build a better one talking about venturi tubes and Bernoulli's principle as though he had thought of them himself. He knows that his section must be of exactly a certain length because he wants a direct reading on the wing tunnel to express the coefficient of lift as opposed to that of the wing built by his neighbor and surface is involved in the formula[2]

$$L = C_L \frac{DS}{2} V^2.$$

Probably no final judgment as to the success or failure of this experiment as a foundation for future work could be made except by a comparison of the hold-over knowledge as demonstrated by these students in their subsequent special science courses as contrasted with that of previous classes taught more conventionally. Judged solely on the basis of pupil-interest and response the author sees some justification for revising general science to a general engineering approach on one basis or another. He is rather certain that its value as a terminal course has been enhanced. Comments and suggestions from other workers in the field will be most welcome.

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[2] *Science of Pre-Flight Aeronautics, op. cit.*, p. 230.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

ONE HUNDRED FIFTY-FOURTH MEETING

NORTHEASTERN UNIVERSITY

360 Huntington Ave., Boston, Massachusetts
Saturday, April 10, 1943

9:45 Meeting of the Executive Committee.

10:00 Address: "Bomb Types and their Destructive Effects."
Emil A. Gramstorff, Chairman Civil Engineering Dept., Northeastern University; Chief Bomb Official, Massachusetts Committee on Public Safety; Regional Consultant New England Office, O. C. D.

10:45 Address: "Practical Electronics Laboratory Equipment."
Carl F. Muckenhoupt, Chairman Physics Department, Northeastern University; Lt. Commander, U. S. Naval Reserve; Sergeant, Newton Auxiliary Police-Radio Division; Supervisor Pre-Radar Training for U. S. Army Signal Corps.

11:30 Address: "Principles of Fluid Forces on Cylinders and Air-Foils."
Chester H. Wolowicz, Instructor in Aeronautical Engineering Northeastern University; Ground School Instructor, War Training Service of C. A. A.

12:30 Luncheon.

1:45 Address: "Uncle Sam's E. S. M. W. T."
Dean William C. White, College of Engineering, Northeastern University; Regional Representative of E.S.M.W.T. on the War Manpower Commission Staff, Region I; Secretary, Engineering Societies of New England.

2:30 Inspection of Library and Laboratories.

Officers:

President: Clarence W. Lombard, High School, Hyde Park, Mass.
Secretary: Carl W. Staples, High School, Chelsea, Mass.
Treasurer: Albert R. Clish, Belmont High School, Belmont, Mass.

Executive Committee:

Hollis D. Hatch, English High School, Boston, Mass.
Charles S. Lewis, Brighton High School, Brighton, Mass.
Louis R. Welch, Dorchester High School for Boys, Dorchester, Mass.

BUSINESS MEETING

Mr. Ralph H. Houser, Mr. John P. Brennan, and Mr. George W. Seaburg were appointed as nominating committee to report at the annual meeting to be held on May twenty-second.

It was voted to extend to the faculty of Northeastern University the appreciation of the association for the use of the building and for the excellent program.

NEW APPARATUS

Mr. Hollis D. Hatch demonstrated additional experiments with an electroscope similar to that described in SCHOOL SCIENCE AND MATHEMATICS, (Vol. XLI, No. 6, June 1941, pages 583–584). The effect of a fountain pen, empty, and also filled with ink was shown. The sensitive rod was covered with tubes of card-board and glass without affecting the working of the instrument. The effect of a charge nearby was shut off when the hand was

held between the charged body and the apparatus. A metal screen prevented the working of the apparatus, unless the metal screen was grounded.

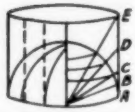
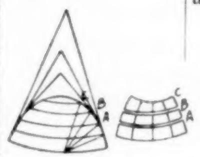
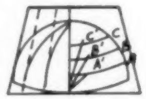
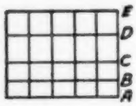
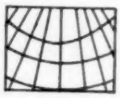
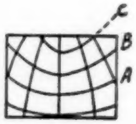
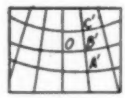
An apparatus for comparing different map projections, constructed by pupils in the North High School in Worcester, Massachusetts, was recently demonstrated by Mr. Carl Johnson.

This apparatus consisted of a 250 cc. round-bottom flask, inverted in the top of a cylindrical base. Thin tape was attached to the spherical part of the flask to represent parallels and meridians. A flashlight bulb concealed in the neck of the flask illuminated the inside of the globe by means of a current furnished by flashlight cells in the cylindrical base. By placing suitable translucent screens near the globe, projections of the meridians and parallels were made illustrating some of the more common schemes of projection found on maps. The screens were (1) rectangular, (2) cylindrical, (3) conical, backed with glass, the conical one, backed by a large glass funnel.

Comparison of Maps. Aeronautics N.H.S.

The accompanying table compares four types of map-projections.

Mercator	*Lambert*	*Polyconic*	*Gnomonic*
I. *Features*			
Mer. 1. parallel 2. equidistant 3. straight	1. Converging straight lines	1. Curved lines except central one	1. Converging straight lines
Lat. 1. Straight lines 2. Perpendicular to meridians	1. Circles 2. Concentric 3. And equidistant	1. Circles of different radius	1. Curved lines
II. *Advantages*			
1. Straight lines give true bearings	1. Course lines nearly great circles 2. Distortion reduced 3. Correct prop. 4. One scale for map	1. Minimum distortion 2. One scale 3. For small areas	1. Great circles straight lines. This permits us to 2. Plot rad. bearings 3. Measure shortest distance between two points
III. *Disadvantages*			
1. Expanding scales 2. Straight line not short 3. Dist. big high lat. 4. Rad. bearing must be corrected for plot.	1. Course lines not accurate 2. Plotting hard 3. Plot. track & traveled track different	1. Course lines incorrect (except short dist.) 2. Difficult to plot	1. Great distortion (except near point of tangency) 2. Different scales

IV. *Uses* 1. Surface Craft 2. Coastal aviation 3. Plotting sheets	Dept. of Commerce 1. Sec. & region maps 2. Commercial maps	1. Army 2. Surveys	1. Gt. circle plotting 2. Plot. radio bear.
V. *Where obtained* Navy (Hydrographic Office)	Dept. of Commerce	U. S. Army	Navy Hyd. Office
VI. *Construction* 			Plane is tangent at 0 
VII. *Appearance when projected* 			

VIII. *Desirable features of map projection—not possessed by any one map*

1. Rhumb line be a st. line
2. A great circle be a st. line
3. Constant scale for all parts
4. Positions easily plotted
5. That areas be rep. in correct prop.
6. True shapes be retained
7. Angles be same

BOMB TYPES AND THEIR DESTRUCTIVE EFFECTS

Abstract of Address by Professor Emil A. Gramstorff

Professor Gramstorff spoke about various types of bombs as distinguished from other falling objects which might be dropped from planes such as car-wheels, rails, gas, incendiaries, etc.

Explosive types were classed as thin and thick case bombs. He described the former as 50 to 2000 kgms in weight with a case thickness of $\frac{3}{16}$ to $\frac{1}{2}$ inch, the main body of seamless steel, with the body welded to a cast steel nose and tail, the latter equipped with stabilizing fins. Dimensions of some of these were given, and the fuse position described as either at the end or side. They were either contact or delayed action types, the latter timed for from .01 second to 4 days.

The thick case types were of cast steel, and more perfectly stream-lined. A small butterfly bomb with a very sensitive fuse was described, which

produced casualties and wounds at distances up to 75 yards, and very dangerous to handle if unexploded.

Block busters with parachutes to give time for planes to get out of the way and to prevent penetration were described. These explode essentially above ground giving a blast effect, and while usually of the contact type, may be delayed action.

Effects were impact and explosion. The impact effect was determined by the elevation and velocity of the plane and the size of the bomb. The damage before explosion constituted the impact effect. The explosion blast, suction wave, and fragmentation have been described in SCHOOL SCIENCE AND MATHEMATICS, Vol. XLII, No. 3, March, 1942, pages 281–285.

A discussion with slides showing the effect on buildings followed. In concrete, the flexure of the slab caused a "scab" which aided in penetration.

The effect of penetration in soil either with or without explosion was pictured. The earth-shock might cause collapse of buildings. Different types of craters and shafts caused by penetration and explosion in soil were explained, and the danger of carbon monoxide in these pockets pointed out.

Professor Carl F. Muckenhoupt gave a talk, demonstrating various types of home-made equipment for teaching electronics. This, he explained did not necessarily mean radio, as there were about five hundred different applications. He gave practical suggestions for the building of apparatus for this type of work.

Professor Chester H. Wolowicz talked on "Principles of Fluid Forces on Cylinders and Air-Foils."

UNCLE SAM'S E. S. M. W. T.

DEAN WILLIAM C. WHITE, *College of Engineering*

No doubt you have been puzzling as to the meaning of the five letters given in the title of this talk. Let me at the outset, therefore, explain that these letters stand for Engineering, Science, and Management War Training. You may be interested in the aims and purposes of this training program because training in the college level in the field of physics forms a definite part of its work.

ORIGIN AND PURPOSE

Originally sponsored by the U. S. Office of Education at the suggestion of a group of leading engineering educators who foresaw two and a half years ago that there would be a serious shortage of technically trained people as the defense program developed, Engineering Defense Training as it was first called, was designed to provide short, intensive courses at the college level to fit men and women for technical jobs in war industries. At first limited to engineering, the program was later broadened to include chemistry, physics, and production supervision, and the title was changed to Engineering, Science, and Management War Training.

Organization and Administration

In a recent reorganization of the War Manpower Commission, ESMWT became one of six components of the Bureau of Training headed by Dr. W. W. Charters. The other five agencies: N.Y.A., Training Within Industry, Vocational Training for War Production Workers, Apprentice Training Service, and Vocational Training for Rural War Production Workers—all are concerned with training at the vocational level and since I assume this audience is primarily interested in the technical and professional personnel, I shall limit myself to a discussion of the college level training program.

This year the agencies which comprise the Bureau of Training are spending over $200,000,000 of government funds in war production training. The $30,000,000 allocated to ESMWT is about the same sum of money that it took to operate all the engineering schools of the country for one year in the middle 1920's at the time of the Investigation of Engineering Education conducted by Dr. Wickenden for the Society for the Promotion of Engineering Education.

The actual administration of ESMWT is handled with notable efficiency in the U. S. Office of Education by a small staff, most of whom are on leave of absence from engineering faculties, under the able leadership of Dean George W. Case of the University of New Hampshire's College of Technology. Participating colleges, now over 200 in number, and including all of the nation's engineering schools, determine the needs of industry in the areas that they serve, propose appropriate courses to meet these specific needs, and assist in placing the trainees where they can be most useful.

Regional co-ordination is provided through 21 part-time regional advisors who serve without compensation and act as chairmen of committees made up of representatives of participating institutions in their areas. The whole program is a spontaneous and voluntary one in which the colleges have cooperated enthusiastically on a non-profit basis. Institutions are reimbursed for the cost of offering ESMWT courses and trainees pay no tuition but are expected to purchase their own text-books and minor supplies.

Types of Courses Offered

The ESMWT program is very flexible and within the limits of its enabling act can serve to meet a wide variety of industrial needs. High School graduation or the equivalent is the minimum requirement for admission to these training courses but many of them require several years of college work or even a college degree as qualification for enrollment. Institutions are free to set up such eligibility requirements as they feel are necessary to the proper conduct of a course and to select the trainees who can be admitted, provided there is no discrimination because of sex, race, creed, or color. Wherever possible employers have been asked to cooperate with the colleges in the selection of suitable trainees.

Two patterns of procedure have developed in the offering of ESMWT courses. In some communities representatives of the colleges have been able

to secure the interest and co-operation of the war industries in a very intimate working relationship whereby the planning and offering of these courses has become in effect a joint enterprise. The manufacturers have carefully analyzed their personnel problems, estimated losses likely to occur through selective service in various categories, studied the particular knowledges and skills that would be needed by replacements, worked out tailormade courses of study with members of the college faculty, assisted in the selection of trainees who would be employable when trained, and finally have placed the people thus trained in the company's employ.

Many times the course is taught by a specialist from industry rather than by a college teacher, and the instruction may even be given off campus at the plant or in rented areas conveniently near it. While the courses offered are all of college grade, they are not traditional units of engineering curricula but are individually designed to meet the specific requirements of definite jobs that industry needs to fill. The plan is flexible enough to provide for training ranging from basic mathematics and mechanical drawing at one extreme to advanced mechanics, X-ray diffraction analysis of metals, geometrical optics, and ultra-high frequency techniques at the other.

It is not always possible to obtain the ideal setup for ESMWT courses in which the trainee's entire program is preplanned, although this is the objective towards which we are constantly striving. Industrial executives are sometimes too busy to give the necessary time for such a program, frequently they can't anticipate their personnel needs adequately, and the smaller companies particularly do not have sufficient staff to warrant running special courses for their own plants alone.

To fill their needs and to provide a pool of trained workers in fields where known shortages exist, the colleges have offered open courses in engineering drawing, motion and time study, production control, industrial safety, metallography, mathematics, tool design, electrical inspection and testing, and similar fields, and have publicized these rather widely with the object of serving people whose value to war production would be enhanced through such training and who would not otherwise be reached. The results of such courses have been very gratifying in that large numbers of the trainees have been upgraded into more responsible jobs in the plants where they were employed, or have been moved from nonessential activities into war-jobs war-production jobs. Some 12,000 short courses of college grade will be offered under ESMWT this year, enrolling over 600,000 trainees.

Pre-employment Courses

It is common knowledge that large numbers of women are being inducted into industry. The competition for the new labor supply is extremely keen. A natural tendency of women who want to do war work, even well-educated women, will be to accept jobs immediately available or available after a very brief paid-while-you-learn training course designed to provide them with the elementary skills needed by machine operators in the production line. Such women have no desire to remain in the labor

market after the war and thus have no personal advantage to gain in preparing themselves for technical service at the professional or semi-professional level.

They can be successfully appealed to, however, to undertake such preparation provided it is possible to do so without too much financial sacrifice. This means that industry must help in the initial selection of such trainees, must put them on its payroll immediately training begins, and must provide opportunity for them to advance in responsibility and in earning power through in-service training after the pre-employment program has been completed. Only through such planning will industry obtain for technical service the capable women it needs and who otherwise will tend to be absorbed in routine jobs far below their abilities.

New England industry has been very slow to recognize this problem. In many other sections of the country, and particularly on the west coast, full-time ESMWT courses are being given to women trainees who are being paid by the companies for whom they are being trained. The courses range from 6 to 16 weeks in length and include training in mathematics, physics, production processes, drawing and elementary engineering mechanics. Sufficient training is given in the pre-employment course to make the trainee initially useful to the company. Obviously a program of supplementary training is necessary for the further development and continuous up-grading of the worker.

An interesting example of pre-employment training of women under ESMWT is the program currently being operated for the Army Map Service. Several hundred senior girls in women's colleges are talking an orientation course in military map-making in the preparation for after graduation jobs with the Army Map Service in Washington. The course comprises an introduction to planimetric and topographic maps, map drafting, projections, military grids and map series, map reproduction methods and photo-mapping in two dimensions. Since the course is only 60 hours in length and carried on top of a full college load, it obviously gives the girls only a start in their new work. Further in-service training is being planned for these girls after they are placed on the job.

Supplementary or In-Service Courses

By far the largest amount of ESMWT training has been of the part-time supplementary type. This will probably continue to be true in the months to come notwithstanding the increased number of pre-employment courses for women which are anticipated. The only way in which industry can hope to maintain the technical personnel that it must have to implement the war-production program is through a continuous process of up-grading. People with potential ability to handle work above the level of that which they are doing must be encouraged to acquire new knowledge and skills through in-service training. The colleges participating in ESMWT will gladly co-operate in organizing and supervising the appropriate courses, but they will need the guidance of industrial executives in laying out the subject matter content and in selecting the trainees most likely to become of greater usefulness in war production as a result of the training.

A specific example may be of interest by way of illustration. One of our ESMWT representatives at Northeastern University discovered that several members of the engineering staff of a large radio manufacturing company were very much in need of a course in ultra high frequency techniques. The head of our electrical engineering department in conference with the chief engineer of the company worked out a combined lecture and laboratory course to meet three evenings a week for 16 weeks. Other radio manufacturers in the area were circularized about the prospective course and many of them designated employees whom they wished to have enrolled. Incidentally the course was limited to college graduates who had majored in electrical engineering or physics and the trainees are not expected to get new jobs as a result of the course but to be more effective in their present positions.

An executive of the electrical manufacturing company that was experiencing difficulty in certain phases of radio tube production suggested a course in glass processing. Such a course was developed and publicized by word of mouth only but the demand for it was so great that four separate sections of the course were organized in various suburban areas of Greater Boston. This is the type of need that ESMWT is prepared to meet.

I have indicated to you how this college level training program now located in the War Manpower Commission's Bureau of Training is co-operating with war industry. ESMWT cannot and does not attempt to produce full-fledged engineers, chemists or physicists capable of general professional service. Perhaps the War Manpower Commission will find a way of channeling a reasonable proportion of young fully trained chemists, physicists, and engineers into the war industry. In the meantime, our colleges and engineering schools stand ready to bridge the gap as effectively as possible through the facilities of the ESMWT program.

There is one aspect of ESMWT that will be of especial interest to your association. About a year ago it became evident that there would be a severe shortage of properly qualified teachers of physics and mathematics both in the secondary schools and in the colleges. Since there was available no other agency of the government prepared to do something about this situation, ESMWT was authorized by Commissioner Studebaker to offer subject matter courses in mathematics and physics for people who needed such training in order to teach in our high schools and colleges. Throughout the country institutions participating in ESMWT have set up refresher courses designed to prepare teachers who have been working in the fields of social sciences, languages, or the humanities for service in mathematics or physics. A large number of teachers were found who originally had considerable training in college mathematics or physics but who had not taught in these fields for many years and so needed refresher courses. Likewise some teachers who had retired or who had left teaching because of being married were willing to come back into service but they also needed a refresher course in order to qualify.

Here in Greater Boston, Harvard, M.I.T., Tufts, and Northeastern have all operated such courses and a new service is planned for this summer. It is obvious that there will be an increasing shortage of teachers, par-

ticularly in mathematics and physics because of the large numbers of instructors who are being taken into the armed services and because of the loss of teaching personnel occasioned by teachers leaving to accept more lucrative jobs in industry. ESMWT is prepared to help to the very limit of the facilities of participating colleges and would welcome your assistance in recommending desirable trainees for these subject matter courses in physics and mathematics.

Please note that ESMWT is not engaged in giving courses in education. We are not prepared and in fact are not allowed under the law to give any work in pedagogy. It is assumed that the people who take these subject matter courses will be teachers who have demonstrated their ability in the classroom in these fields many years ago, or in other fields more recently, and that they will need not training in educational methods, but training in the specific subject matter they will be called upon to handle. It is our desire to admit to these courses for teachers only those who are employable in the teaching field after they have taken the courses. Consequently, we ask the endorsement of a responsible school official on the application of each candidate.

I might mention also, that for areas in which it is not possible to set up classroom instruction in mathematics and physics, ESMWT is prepared to offer correspondence study. These are the only fields in which any correspondence work is carried under the ESMWT program, but the need was so acute, particularly in some of the southern and middle western states, that it seemed that correspondence study was better than no program at all.

A very careful syllabus of a course in mathematics and another in physics has been worked out by the staff at the University of Wisconsin in co-operation with teachers who have had a great deal of experience in correspondence work at other institutions. A small group of universities having well established departments of correspondence study have been designated to give the instruction. I mention this not that I think people in New England will need to resort to correspondence study, but because it does indicate the critical need for teachers of mathematics and physics throughout the country. ESMWT always prefers to set up classroom instruction if this is possible but in some sections of the country this is not feasible and the correspondence work thus supplies a special need.

DR. SYLVANUS G. MORLEY RECEIVES LOUBAT PRIZE OF COLUMBIA UNIVERSITY

The $1,000 Loubat Prize of Columbia University has been awarded to Dr. Sylvanus G. Morley, archaeologist of the Carnegie Institution of Washington, D. C. His monumental work, The Inscriptions of Peten, includes virtually all the material known of the old Mayan empire of Central America and is regarded by archaeologists as of great importance in furthering research in the New World.

THE RELATIONSHIP OF THE STUDY OF MATHEMATICS TO Q-SCORES ON THE ACE PSYCHOLOGICAL EXAMINATION

MELVIN W. BARNES
University of Illinois, Urbana, Illinois

In its recent editions, the American Council on Education Psychological Examination includes six tests: three quantitative tests yielding the Q-score, and three linguistic tests yielding the L-score. Several studies have indicated that college students over periods of two to four years improve in ability to score on the ACE Test. This improvement, of course, may be due to a number of causes. It seems plausible to assume that the study of certain subjects may be related to the kinds of tasks presented by the tests in such a way that the pursuit of these studies would lead to an increase in ability to handle the tests. This could be true either because college studies give a greater familiarity with the content of the tests, or because such studies cultivate mental abilities and increase mental power.

The present study is an attempt to answer the question: Does the study of mathematics in college affect ability to score on the quantitative tests? The first of the three quantitative tests presents problems in arithmetic; the second, in number series; and the third, in figure analogies. Since these tests require computational ability and the capacity to deal with quantitative terms and problems, it seemed reasonable to inquire whether mathematical practice of the nature offered in college courses in mathematics is related to the ability to score on these tests.

In a test-retest experiment, seventy-five university students who had completed the freshman-sophomore years without having had a course in college mathematics were compared with forty mathematics students who had also completed the first two years of college work. Although the mathematics students were not necessarily intending to major in that subject they had had an average of slightly over 8 semester hours each of mathematics during their first two years in the university.

The first test, the 1940 edition of the ACE Psychological Examination, was administered to the total group at the beginning of their freshman year, September, 1940. The retest was given, again to the total group, at the end of the sophomore year, May 1942. In order to reduce the possibility of practice effect, the

retesting was done with the 1939 edition of the ACE Test. The two editions are equivalent in all respects except that the 1939 edition is somewhat more difficult than the 1940 edition. Raw scores between the two forms of the test, therefore, cannot be directly compared. The performance of the two groups of students is summarized in the following table.

Q-SCORES OF MATHEMATICS STUDENTS COMPARED WITH Q-SCORES OF NON-MATHEMATICS STUDENTS

Group	Number	Initial test (1940 edition)			Retest (1939 edition)		
		Mean Q-score	Differ-ence	Criti-cal Ratio	Mean Q-score	Differ-ence	Criti-cal Ratio
Mathematics Students	40	46.65	4.10	.44	41.78	5.04	.67
Non-mathematics Students	75	42.55			36.74		

The data contained in the table indicate that the mathematics students did not significantly surpass the non-mathematics students. A slight gain in favor of the former group is evident, but it is by no means significant. In this instance, then, the study of mathematics did not increase ability to handle the quantitative tests.

It is interesting to note that the students choosing mathematics were superior in ability as measured by the total score on the ACE Test to those not taking mathematics. The mean of the gross scores of the mathematics group was 121.45; that of the non-mathematics group was 100.00. In the latter group, the spread of scores was somewhat greater, a standard deviation of 25.34 being found for the scores of the non-mathematics students and a standard deviation of 18.28 for the scores of the mathematics students.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink.

Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

K

LATE SOLUTIONS

1804. *R. W. Franbel, Ann Arbor, Mich.*
1801, 4. *M. Freed, Wilmington, Calif.*
1809. *Everett H. King, Macomb, Ill.*
1808, 9, 10, 11, 12. *J. Frank Arena, Hardin, Ill.*
1808. *Alan Wayne, Flushing, L. I., N. Y.*

Editor's Note: The solution of 1803 was by Malcolm Kirk, West Chester, Pa. and the answer should have been given as $-\frac{5}{8}$.

1813. *Proposed by Anna McGreegen, Marcellus, N. Y.*

If n is an odd integer and not divisible by 3, prove that n^2+5 is divisible by 6.

Solution by M. I. Chernofsky, Brooklyn, N. Y.

If n is odd and not divisible by 3, it must be of the form $6a\pm1$ where $a=0, 1, 2, 3, \cdots$. In either case, $n^2+5=36a^2\pm12a+6$, which is obviously divisible by 6.

Solutions also were offered by Malcolm Kirk, West Chester, Pa.; Wayne Cowell, Clay Center, Kan.; D. F. Wallace, St. Paul, Minn.; W. R. Smith, Suttons Bay, Mich.; and Aaron Buchman, Buffalo, N. Y.

1814. *Proposed by Leona Henry, Valley Forge, Pa.*

If A, B, C, D be four consecutive vertices of a regular heptagon inscribed in a circle of radius unity, show that $AC+AD-AB=\sqrt{7}$.

Solution by W. R. Smith, Suttons Bay, Mich.

The angle subtended by

$$AB=\frac{360^\circ}{7}=51^\circ25'43''.$$

Also

$$OAB=\frac{180^\circ-\angle AOB}{2}=64^\circ17'9''.$$

In like manner

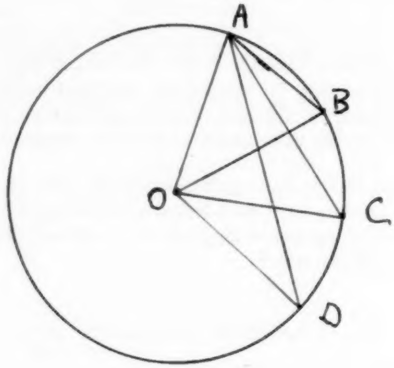
$$\angle OAC=38^\circ34'17''$$

and

$$\angle OAD = 12°51'26''.$$

From isoceles $\triangle AOB$,

$$AB = 2 \cos OAB = .86778.$$



Also in like manner,

$$AC = 2 \cos OAC = 1.56366$$

and

$$AD = 2 \cos OAD = 1.94986.$$

Hence $AC + AD - AB = 2.64574$ which is also the value of $\sqrt{7}$, approximately.

A solution was also offered by J. Frank Anana, Hardin, Ill.

1815. *Proposed by Paul C. Overstreet, Wilmore, Ky.*

Water is flowing into a vertical cylindrical tank at the rate of 100 gallons per minute and is flowing out through a one square inch opening in the bottom of the tank. If the area of the cross section of the tank is one square foot, how long will it be before the water in the tank reaches a permanent level?

Solution by the proposer

$$\begin{aligned}\text{Rate of rise of water due to inflow} &= \frac{23{,}100 \text{ in.}^3/\text{min.}}{144 \text{ in.}^2}\\ &= 160.4 \text{ in./min.}\\ &= .223 \text{ ft./sec.}\end{aligned} \tag{1}$$

Rate of escape of water through orifice $= \sqrt{2gy} = 8\sqrt{y}$ where y is the depth of the water in the tank, in feet.

Rate of sinking of water in the tank due to escape through orifice is $1/144$ of that of the rate of flow through the orifice, which is

$$.0556\sqrt{y} \text{ ft./sec.} \tag{2}$$

Hence,

$$dy/dt = .223 - .0556\sqrt{y}. \tag{3}$$

The permanent level will be reached when $dy/dt=0$. Hence,

$$.0556\sqrt{y}=.223$$
$$y=16.$$

Equation (3) may be rewritten in the form from which

$$dt=dy/(.223-.0556\sqrt{y}) \qquad (3')$$

$$t=\int_0^{16} dy/(.223-.0556\sqrt{y}). \qquad (4)$$

Since this form is not easily integrated, let $-\sqrt{y}=z$. Then $y=z^2$, and $dy=2z\ dz$.

Equation (4) now becomes

$$t=2\int_0^{256} z\,dz/(.223+.0556z)$$

or

$$t=2/(.0556)^2\cdot\left[.223+.0556z-.223\log_e(.223+.0556z)\right]_0^{256},$$

$$t=8787 \text{ seconds}=2 \text{ hours } 26 \text{ minutes.}$$

A solution was offered also by W. R. Smith, Suttons Bay, Mich.

1816. *Proposed by Julius Brandstatter, Los Angeles, Calif.*

Find a triangle with integral sides and area, such that the distances from A, B and C to the center of the inscribed circle shall be integers.

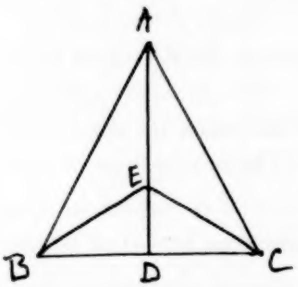
A special solution has been offered by D. F. Wallace, St. Paul, Minn. A satisfactory, complete solution has not yet been offered.

A triangle whose sides are $100x$, $100x$ and $56x$, where x is any integer, is a triangle such as is described in the problem.

Proof:

In triangle ABC, $AB=AC=100x$, $BC=56x$, where x is any integer.

Draw AD perpendicular to BC. AD bisects BC and $BD=28x$.



$$AD^2=AB^2-BD^2=10000x^2-784x^2=9216x^2.$$

Therefore

$$AD=\sqrt{9216x^2}=96x.$$

The area of $\triangle ABC=96x\cdot 28x=2688x^2$. Since x is an integer $2688x^2$ is an integer. Therefore $\triangle ABC$ has an integral area and also, since x is an integer, its sides are integral.

Draw BE, bisecting $\angle ABC$, meeting AD at E. Then

$$\frac{AB}{AE}=\frac{BD}{AD-AE} \quad \text{or} \quad \frac{100x}{AE}=\frac{28x}{96x-AE}. \tag{1}$$

After clearing fractions in (1) transposing and combining terms, we have:

$$128AE\cdot x=9600x^2. \tag{2}$$

Dividing (2) by x: $128AE=9600x$, whence $AE=75x$. Therefore

$$DE=21x.$$

$$BE^2=DE^2+BD^2=(21x)^2+(28x)^2=441x^2+784x^2=1225x^2.$$

Therefore $BE=\sqrt{1225x^2}=35x$ also $CE=BE=35x$ because DE is perpendicular to BC at its midpoint.

AE, BE and CE being equal to integers multiplied by integers are integers.

AE is bisector of $\angle BAC$ and BE is bisector of $\angle ABC$.

Therefore E is the center of the inscribed circle of $\triangle ABC$.

Therefore the distances from A, B, C to the center of the inscribed circle are integers.

When $x=1$ the sides of ABC are 100, 100 and 56.

A solution was offered also by the proposer.

1817. *Proposed by Don Marshall, Dearborn, Mich.*

In scalene triangle ABC, $AC=3$ in., the altitude from B is 5 in. and angle $B=18°$. Find length of AB.

Solution by Aaron Buchman, Buffalo, N. Y.

Let $AB=x$, and $BC=y$. From the formulas for the area of a triangle,

$$\tfrac{1}{2}\cdot x\cdot y\cdot \sin 18°=\tfrac{1}{2}\cdot 3\cdot 5, \quad \text{or} \quad xy=15\csc 18°. \tag{1}$$

From the law of cosines,

$$9=x^2+y^2-2xy\cos 18°. \tag{2}$$

Using (1) to replace xy in (2) and solving for x^2+y^2,

$$x^2+y^2=9+30\cot 18°. \tag{3}$$

Adding twice (1) or (3) and taking the square root,

$$x+y=(9+30\cot 18°+30\csc 18°)^{1/2}=\pm 14.08. \tag{4}$$

Subtracting twice (1) from (3) and taking the square root,

$$x-y=(9+30\cot 18°-30\csc 18°)^{1/2}=\pm 2.06. \tag{5}$$

Solving (4) and (5) for positive values of x, $AB=8.07$ or 6.01.

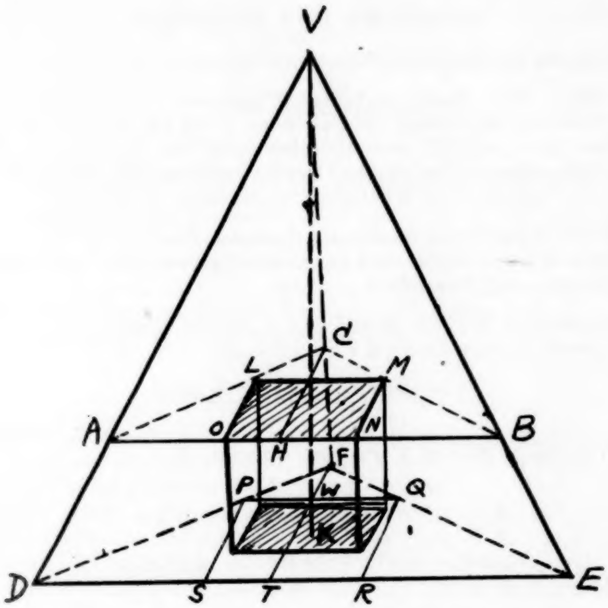
Solutions were offered also by D. F. Wallace, St. Paul, Minn.; M. Kirk, West Chester, Pa. and the proposer.

1818. *Proposed by Hugo Brandt, Chicago, Ill.*

a. In an acute angled triangle, with base b and altitude h, inscribe a square with side s whose base is colinear with the triangle's base, while the other two corners lie on the triangle's other two sides.

b. Find an expression for s in term of b and h.

c. With the triangle of problem (a) as base erect a pyramid (tetrahedron) of altitude a, in which inscribe a cube of side s_1 whose base is coplan or with the triangle and whose top face is inscribed, as in (a), in the smaller triangle that forms the intersection of its plane with the pyramid. Find an expression for s_1 in terms of b, h and a.



Solution by Alan Wayne, Flushing, N. Y.

(a) On $FT=h$ make $FW=(h-s)$; draw $PQ \parallel DE$; drop $\perp$s PS, QR.

(b) Since $\triangle FPQ \sim \triangle FDE$, $\dfrac{h-s}{s}=\dfrac{h}{b}$ whence $s=\dfrac{bh}{b+h}$.

(c) Since $\triangle ACB \sim \triangle FDE$, $\dfrac{s_1}{s}=\dfrac{a-s_1}{a}$ where $VK=a$.

Whence

$$s_1=\frac{as}{a+s}.$$

Substituting from (b):

$$s_1=\frac{abh}{ah+ab+bh}.$$

Solutions were offered also by W. R. Smith, Suttons Bay, Mich., and the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below:

1808, 9, 11. K. A. G. Miller, Upper Canada College, Toronto, Canada.

1801. Arthur Harp and Floyd Lofthus, Wilmington, Calif.

PROBLEMS FOR SOLUTION

1831. *Proposed by Arthur B. Hussey, New Rochelle, N. Y.*

Mrs. Allen, Mrs. Bates, and Mrs. Clark, and their three daughters bought cloth and lace. Each paid as many cents per yard as she bought yards. Each lady paid 63¢ more than her daughter. Jane bought 23 yards less than Mrs. Allen; Eliza bought 11 yards less than Mrs. Bates. The other daughter was named Ann. What was the full name of each girl?

1832. *Proposed by Walter R. Warne, Rochester, N. Y.*

Resolve into three factors each of second degree in α, β, γ, the expression $(\alpha+\beta+\gamma)^3\alpha\beta\gamma-(\alpha\beta+\alpha\gamma+\beta\gamma)^3$.

1833. *Proposed by William Meddick, Los Angeles, Calif.*

If y is positive, show that $\log y$ lies between

$$\frac{2(y-1)}{(y+1)} \text{ and } \frac{y^2-1}{y}.$$

1834. *Proposed by Phillip S. Perkins, Camden, N. J.*

Given:

$$x+y+z=1$$
$$x^2+y^2+z^2=2$$
$$x^3+y^3+z^3=3.$$

Prove

$$x^4+y^4+z^4=4\tfrac{1}{6}.$$

1835. *Proposed by Hugo Brandt, Chicago, Ill.*

If a hen and a half lays an egg and a half in a day and a half, how many hens lay how many eggs in the smallest (integer) number of days if the sum of the number of hens, eggs and days is 100?

1836. *Proposed by Myrtie Hyatt, Newburg, N. Y.*

The difference of the squares of any two odd integers is divisible by 8.

CORRECTION:—In problem 1828 the dominator should have the exponent "2". EDITOR.

SCIENCE QUESTIONS

June, 1943

Conducted by Franklin T. Jones
10109 Wilbur Avenue, S.E., Cleveland, Ohio

Contributions are desired from teachers, pupils, classes and general readers. Send examination papers from any source whatsoever.

It is natural that questions connected with the War Effort will be especially appreciated.

Questions on any part of the field of science; questions having to do with the pedagogy of science; new applications of old ideas; present variations of perhaps ancient questions; anything that appeals to the reader, or might appeal to other readers—all are wanted.

What interests you will most likely interest others also.

We will endeavor to obtain answers to all reasonable questions. It is always valuable to get questions whether we can get the answers or not.

Contributors to SCIENCE QUESTIONS are accepted into the GQRA (Guild of Question Raisers and Answerers).

Classes and teachers are invited to join with others in this cooperative venture in science.

JOIN THE GQRA!

SCRAPBOOK PICTURES OF GQRA MEMBERS

It has been suggested to the Editor that a book of pictures of members of the GQRA should be prepared. It is true that many of the contributors to SCIENCE QUESTIONS are and have been leaders in Science and Mathematics affairs, and that such a collection of pictures would provide important information concerning educational leaders during the period since 1910.

Please send in your picture—snapshot or otherwise.

SCIENCE AND INDUSTRY

Send for free copies: Get yourself and classes on Mailing Lists: Read yourself and have your pupils read; Many of these Articles are better than the Textbooks and much more interesting.

48. STEEL FACTS, February, 1943. *Free.* Write to American Iron and Steel Institute, 350 Fifth Avenue, New York, N. Y. "$1,205,000,000 Spent on Plants by Steel Mills since Hitler entered Austria."
49. STEEL FACTS, April, 1943. *Free.* "Steel Spans the Continent" (Illustrated).
50. REPUBLIC REPORTS, March, 1943. For Republic Employees, probably available by applying to Republic Steel Corporation, Cleveland, Ohio. (Very fine Flow Charts).
51. "*Your Body's Battle for Life*"—RCA Electron Microscope, "Complete data and literature are available on request." Radio Corporation of America, Camden, New Jersey.
52. "*Bausch and Lomb at War*"—Bausch & Lomb Optical Co., Rochester, N. Y. Optical Instruments of War (Profusely illustrated).
53. "*Glass Goes to Town*"—*National Geographic* Magazine, January, 1943. (Illustrated).
54. "The High School Victory Corps Goes to War"—OHIO SCHOOLS, April, '43. Lincoln High School, Cleveland, Ohio, mobilizes its entire student body. *Read to appreciate.*
55. "*The Electron*"—by J. D. Ratcliff, *COLLIER'S WEEKLY*, April 24, 1943. "An infinitesimal giant goes to work for science." *Read.*
56. "*Fire—Its Basic Principles and Simple Chemistry*"—*LIFE*, April 26, 1943. Experiments by Professor A. R. Davis, of Massachusetts Institute of Technology—Beautifully illustrated.
57. OPPORTUNITIES IN THE UNITED STATES MERCHANT MARINE—Vocational Division Leaflet No. 9, U. S. Office of Education. Price 5 cents (But you probably were on the mailing list for a *free* copy. Ask anyway).

BLOWING BUBBLES

From SCIENCE NEWS LETTER, April 17, 1943, page 253.

1006. What makes wheat flour better for bread than any other cereal?

Answer—Gluten. Gluten is the balloon that holds the carbon dioxide bubbles set free by the yeast.

Question—Can you raise straight rye flour? Why?

Answer—No. No gluten in rye flour. Raised rye bread has to have wheat flour mixed with the rye in order to get a leavened loaf.

GROCER FILLS PRESCRIPTION FOR VITAMINS

From SCIENCE NEWS LETTER, April 17, 1943, page 252

1007. How can a grocer fill a prescription for vitamins?

At the meeting of the Chicago Dental Society, Dr. Edward H. Hatton, Northwestern University, professor of pathology and bacteriology, declared:

"Sufficient vitamins can and should be eaten at the family dinner table as wholesome and sufficient foods."

"Possibly the only vitamin concentrates that merit general use, and then only during the winter months, are A and D, either as concentrates or in the form of cod liver oil preparations." "Foods should also be the prescription for minerals."

1008. How many B-Vitamins are there?

Answer—Twelve: Thiamin, niacin, riboflavin, folic acid, biotin, inositol, *p*-aminobenzoic acid, pantothenic acid, pyridoxine, choline, two factors needed by chicks, and one or more needed by guinea pigs.

SARAN PIPE

From an enclosure to stockholders of Dow Chemical Company.

1009. What is Saran Pipe?

Answer—Saran pipe is a plastic pipe that, in many places, can replace strategic materials such as metals and rubber.

"A two-inch saran pipe can be completely welded in less than one minute. . . . Two lengths of saran pipe are placed on a nickel surfaced hot plate—then pressed together—allowed to cool for a few seconds—and the entire operation is completed! The welded joints become equal in strength to any other portion of the pipe itself." Save time as well as materials.

RUBBER—GIFT WITHOUT PRECEDENT

1010. *News Item, April 21, 1943, and Advertisement of Standard Oil of New Jersey concerning:*

FACTS ABOUT BUNA

In 1929 we bought from I. G. Farbenindustrie of Germany a minor interest in their Buna rubber processes for use outside Germany.

During the 1930's these processes were further developed. The quality of Buna was improved, the range of its use widened.

In 1939—two years before Pearl Harbor—we bought out *all* German rights in the Buna processes for the U. S. A. Soon after, two large tire companies took out licenses. We also began building a Buna rubber plant of our own.

When war threatened the loss of our country's natural rubber supply, authorities agreed that Buna-S was America's best bet for tires. It became the basis of the Government's synthetic tire program.

Today the Government is spending over six hundred million dollars on its Buna-S program. Six rubber plants are in operation. By the end of 1943 completed plants will have a capacity of 705,000 tons per year, or more than the entire peacetime rubber requirements of the United States.

"For more than a year," says Ralph W. Gallagher, President of Standard Oil, N. J., "this company's Buna rubber patents have been royalty-free to everybody for the duration of the war."

The Government will have a free license for itself not only during the war, but for the entire life of the patents.

During the war the Government will have the right to issue royalty-free licenses for the entire life of the patents to everyone who co-operates with the Government in its rubber program and reciprocates with similar licenses under its own patents.

There will be no payments to us (Standard Oil) or to others for the patent rights used.

The Government will increase its expenditures on synthetic rubber research to a total of not less than $5,000,000.

"The Government's Rubber Director and Rubber Reserve Company have accepted this proposal. This is the first time, to our knowledge, that any company has offered to Government the right to license important patents—royalty-free—forever—to everyone—even to its competitors." (R.W.G.)

The Years 1942 and 1943 have marked unprecedented advances in the Teaching and Recognition of SCIENCE AND MATHEMATICS.

What we do in succeeding months and years to preserve this advance is the concern of the next few months!!!

In Summertime Prepare for Fall!
Are We Ready? And What Shall We Do?
Send in Your Answers and Questions!

JOIN THE GQRA!

BOOKS AND PAMPHLETS RECEIVED

ELEMENTS OF FOOD BIOCHEMISTRY, by William H. Peterson, Ph.D., *Professor of Biochemistry, University of Wisconsin, Madison, Wisconsin;* John T. Skinner, Ph.D., *Assistant Chemist, Kentucky Agricultural Experiment Station, Lexington, Kentucky;* and Frank M. Strong, Ph.D., *Associate Professor of Biochemistry, University of Wisconsin, Madison, Wisconsin.* Cloth. Pages xii+291. 14.5×23 cm. 1943. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $3.00.

APPLIED MECHANICS AND HEAT, by L. Raymond Smith, *Instructor in Industrial Physics, William L. Dickinson High School, Jersey City, New Jersey.* Cloth. Pages xii+326. 12.5×19 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.00.

STUDY ARITHMETICS, Book 4, by J. W. Studebaker, W. C. Findley, F. B. Knight, and G. M. Ruch. Cloth. 352 pages. 13×20 cm. 1943. Scott, Foresman and Company, 623 S. Wabash Avenue, Chicago, Ill. Price 88 cents.

SHOPWORK, WRITTEN TO CONFORM TO THE PREINDUCTION TRAINING COURSE IN FUNDAMENTALS OF SHOPWORK AS PREPARED BY THE WAR DEPARTMENT, by Edward C. Wicks, *Instructor in Industrial Arts, Morristown High School, New Jersey;* John Poliacik, Jr., *Instructor in Industrial Arts,*

Morristown High School, New Jersey; and John Ellberg, *Author of "Tales of a Rambler."* Cloth. Pages viii+160. 15.5×23.5 cm. 1943. American Book Company, 360 N. Michigan Avenue, Chicago, Ill.

RADIO—1, WRITTEN TO CONFORM TO THE PREINDUCTION TRAINING COURSE IN FUNDAMENTALS OF RADIO AS PREPARED BY THE WAR DEPARTMENT, by R. E. Williams, *Manager, School Service, Westinghouse Electric and Manufacturing Company, Pittsburgh, Pennsylvania,* and Charles A. Scarlott, *Editor, Westinghouse Engineer.* Cloth. Pages x+132. 15.5×23.5 cm. 1943. American Book Company, 360 N. Michigan Avenue, Chicago, Ill.

FUNDAMENTALS OF ELECTRICITY, BASED ON MATERIAL DEVELOPED FOR THE TEACHING OF LEARNERS AND APPRENTICES OF THE CARNEGIE-ILLINOIS STEEL CORPORATION. REWRITTEN TO CONFORM TO THE PREINDUCTION TRAINING COURSE IN FUNDAMENTALS OF ELECTRICITY AS PREPARED BY THE WAR DEPARTMENT. Cloth. Pages vii+194. 15.5×23.5 cm. 1943. American Book Company, 360 N. Michigan Avenue, Chicago, Ill.

AUTOMOTIVE MECHANICS—1, WRITTEN TO CONFORM TO THE PREINDUCTION TRAINING COURSE IN FUNDAMENTALS OF AUTOMOTIVE MECHANICS AS PREPARED BY THE WAR DEPARTMENT, by Clarence G. Barger, *Instructor of Automotive Mechanics, Brooklyn High School of Automotive Trades, New York.* Cloth. Pages vii+166. 15.5×23.5 cm. 1943. American Book Company, 360 N. Michigan Avenue, Chicago, Ill.

APPLIED MATHEMATICS FOR TECHNICAL STUDENTS, By Murlan S. Corrington, M.Sc., *Formerly, Rochester Athenaeum and Mechanics Institute, now Radio Engineer, Advanced Development Division, Radio Corporation of America, RCA Victor Division.* Cloth. Pages ix+226. 13.5×21.5 cm. 1943. Harper and Brothers, 49 E. 33rd Street, New York, N. Y. Price $2.20.

BASIC ELECTRICITY, by Wilbur L. Beauchamp and John C. Mayfield. Cloth. Pages viii+312. 19.5×28 cm. 1943. Scott, Foresman and Company, 623 S. Wabash Avenue, Chicago, Ill. Price $1.60.

THE STORY OF FLYING, by Archibald Black, *Author of "The Story of Bridges"; "The Story of Tunnels"* etc. Revised Edition. Cloth. Pages xiv +272. 15×23 cm. 1943. Whittlesey House, McGraw-Hill Building, 330 W. 42nd Street, New York, N. Y. Price $2.50.

FACTORS AFFECTING STUDENT ACHIEVEMENT AND CHANGE IN A PHYSICAL SCIENCE SURVEY COURSE, by Waldo Lyle Brewer, Ph.D. Teachers College, Columbia University Contributions to Education, No. 868. Cloth. 78 pages. 14.5×23 cm. 1943. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.60.

LABORATORY MANUAL IN RADIO, by Francis E. Almstead, *Lieut., U.S.N.R. Material Officer, U. S. Naval Training School, Noroton Heights, Connecticut;* Kirke E. Davis, *Head, Science Department, Oceanside High School, Oceanside, New York;* and George K. Stone, *Senior Education Supervisor, The State Education Department, Albany.* Paper. Pages vii+139. 15×23 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price 80 cents.

MATHEMATICS DICTIONARY, by Glenn James, *Associate Professor of Mathematics, University of California at Los Angeles,* and Assisted by Robert C. James, *Teaching Fellow in the California Institute of Technology.* Revised Edition. Cloth. Pages viii+274+46. 15×23 cm. 1943. The Digest Press, Van Nuys, Calif. Price $3.00.

The Balance of Power, by Edward Vose Gulick. Paper. Pages iv+59. 14×21.5 cm. The Pacifist Research Bureau, 1201 Chestnut Street, Philadelphia, Pa. Price 25 cents.

The Rockefeller Foundation, A Review for 1942, by Raymond B. Fosdick, *President of the Foundation*. Paper. 64 pages. 15×23 cm. The Rockefeller Foundation, 49 W. 49th Street, New York, N. Y.

A Course in the Fundamentals of Electricity, by Morton Mott-Smith, Ph.D., *Science Service Staff Writer in Physics*, with Collaboration of the Staff of Science Service. Paper. 65 pages. 21×25.5 cm. 1943. Science Service, 1719 N Street, Northwest, Washington, D. C. Price 15 cents each, 10 copies for $1.00.

On the Petsamo Road, Notes of a War Correspondent, by K. Simonov. Paper. 47 pages. 12.5×19 cm. Foreign Languages Publishing House, Moscow.

Soviet Women in the War Against Hitlerism, by L. Ozerov and others. 76 pages. 13×20 cm. Foreign Languages Publishing House, Moscow.

BOOK REVIEWS

Elements of Radio, by Abraham Marcus and William Marcus, Prepared under the Editorship of Ralph E. Horton. Cloth. Pages xiii+699. 15×22.5 cm. 1943. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Text Edition (Special Edition for Schools Only), One Volume $3.20. Two Volumes $1.96.

Recent demands of the war and navy departments for great numbers of men and women trained in the use of radio equipment has brought out an unusual supply of books in the radio field. Many of these are advanced texts cut down or "simplified" in an attempt to meet the needs of students who have neither a knowledge of electricity nor radio circuits. Many of these books are of little value to the boys who must learn the fundamentals of radio in a very short time. The authors of this text have supplied a book for beginners—for those who know nothing about electrical circuits. But they have not found it necessary to forget all about radio until the fundamentals of electricity have been learned. Every idea presented is used immediately and it is completely explained. Over five hundred illustrations are used to clarify the discussions. Each chapter presents in general one complete idea. Each is followed by a summary, a glossary, and a list of questions and problems. No mathematics is used in the first half of the book; it is purely descriptive and explanatory. The second half of the text introduces some important mathematical ideas but all are completely explained and illustrated. It is the reviewer's judgment that this book will meet the demands and prepare many students for the work so vital to war success and for ordinary future demands.

G. W. W.

Physical Science, by William F. Ehret, *Professor of Chemistry*, Leslie E. Spock, Jr., *Associate Professor of Geology*, Walter A. Schneider, *Associate Professor of Physics*, Carel W. van der Merwe, *Professor of Physics*, and Howard E. Wahlert, *Instructor in Mathematics, all of Washington Square College of Arts and Science, New York University*. Cloth. Pages 10+639. 15×23.5 cm. 1942. The Macmillan Company, New York. Price $3.90.

After looking over a number of inferior survey-science texts it is pleasurable to read one which seems to be based upon higher standards than usual. The authors are consistent in avoiding unqualified generalizations, this in a book of generalizations. They call attention to the difference between "law," "theory," and "hypothesis," not only in a preliminary chapter, which is about the only time most authors remember the distinction, but throughout the remainder of the book as well. This reviewer found no serious factual errors, although it must be admitted that he is not enough of a specialist in each of the fields touched upon to discover all that might be present. The cautious treatment of subject matter gives one a sense of confidence in the accuracy of the work.

It seems that almost every major topic in the fields of astronomy, geology, meteorology, physics and chemistry as well as quite a little mathematics have been touched upon, save for one surprising exception, there is no mention of centrifugal (or centripetal) forces. One will be amazed at the amount of material compacted into this book.

But the material is too compacted, too much a matter of fact upon fact, principle upon principle, generalization upon generalization. All this material must be accepted, learned blindly without application, unless the student has already a rich science background to build upon.

Neither can the usual run of college freshmen, who are the ones generally thrust into a survey course, appreciate the care that the authors took in maintaining a proper scientific attitude. A book that attempts to touch upon every major phase of physical science from electrons to spiral nebulae can hardly give much space to discussion of each topic. And when the authors believe in "rigorous" treatment, the discussion quickly becomes abstract. Imagine college freshmen trying to picture the reason for infrequency of eclipses from a single sentence (p. 47). And think of them confronted with an explanation which refers to "root mean square velocity" (p. 149). One can not expect them to spend much time admiring the cautious treatment of controversial issues.

The illustrations will do little to help the weakly prepared student. Many are diagrams of apparatus used in research. The photographs are few and these have not reproduced well.

Each chapter contains a set of references and one or more sets of problems, many of which are mathematical. Most of the latter are standard in physics or chemistry texts.

The book can be recommended only for college freshmen classes that are composed of students entering with a sound background in physics and chemistry; other students probably can not use the book advantageously. The book also might find use in a survey course designed for upperclassmen who have completed work in the fundamentals and who now wish to see the physical science field as a whole.

The authors believe that demonstrations, lantern slides and motion pictures are not "necessary concomitants of the text." This reviewer states emphatically that such aids are necessary, and that the book needs much supplementary explanation to make it usable.

WALTER A. THURBER

EVERYDAY SCIENCE, by Otis W. Caldwell, *Professor Emeritus, Teachers College, Columbia University* and Francis D. Curtis, *Head of the Department of Science, University High School, and Professor of the Teaching of Science, University of Michigan*. Cloth. Pages xiii+664. 16×23 cm. 1943. Ginn and Company, New York. Price $1.96.

The authors have revised and added to their useful book, "Science for Today," which they produced some years ago. The result is a better gen-

eral science text with a less apt title, since a large share of the material is only vicariously a part of a ninth-grader's everyday life.

The factual material is wisely limited; there are few of the absurd extensions of subject matter which mark so many ninth grade texts. In general, the material is carefully presented although the section on astronomy does not bear up well under careful scrutiny. We find that stars travel "like a swarm of insects" (p. 242), that meteors "wander" about (p. 258), that the earth rotates exactly once in twenty-four hours (p. 251 and p. 279), and that centrifugal force makes a whirling body move outward from the center (p. 245). Also the solar system diagram on page 249 fails to state that two radically different scales, one for size and one for distance, are used.

This reviewer dislikes Chapter XX on the nature of matter. He believes that it is as unscientific to force the molecular and atomic theories on defenseless school children as it was to tie Galileo to the stake. This book does not even refer to these explanations as theoretical.

In an effort to keep the book up-to-date over the next few years the authors refer to the "Second World War" in the past tense. This makes a present-day reader feel something like Rip Van Winkle.

The book is profusely illustrated with excellent diagrams and photographs. Particularity in the selection of captions is evident. In the captions there are usually included questions, some of which may be answered by looking at the pictures but others of which, unfortunately, can be answered only by guessing. Occasionally pictures and captions seem but remotely connected, as on page 439 where a photograph of skaters snapping the whip is accompanied by the remark that 100 acres of corn give off enough water to cover one square mile with an inch of ice.

Composition is admirable; several contrasting type faces and a good balance of line cuts and half-tones break up the pages. One's attention is captured merely by thumbing through the book.

There are several special features such as self-tests which contain a careful selection of questions. There are also suggestions for supplementary activities which give hints where data might be found, thus showing that the authors are conscious of one of the big problems of classroom teachers. Unfortunately, the authors seem to forget that data can be collected from sources other than encyclopedias; data-collection at first-hand is really the more important from a scientific standpoint.

In spite of its shortcomings, which are often more exaggerated in other texts, this book is among the best of recent editions. It will serve as a tool for a teacher as well as a reference; inexperienced teachers may follow it safely because its organization is sound, its demonstrations and experiments are easy to perform, and there is a minimum of material which can embarrass a teacher who does not have a thorough preparation in science.

WALTER A. THURBER

STRENGTH OF MATERIALS, by Merriman—revised by Edward K. Hankin, *Coordinator, Murrell Dobbins Vocational School, Philadelphia, Pennsylvania.* Eighth Edition, pages viii and 148. 71 Figures. 8 Tables. 13 cm. ×22 cm. Cloth. List Price $1.50. John Wiley & Sons, New York. 1942.

In the revision of this book the author expresses in the preface his desire to convey subject matter in the language understood by secondary school level or vocational school groups rather than by the erudite person with formal engineering training. The initial chapter, consequently, is concerned with orientating the student in the most practical language to the work ahead. In this effort it is apparent that the objective has been accomplished.

The author was also mindful of the need of elimination of material more

or less ancient and confined and replacing it with subject matter of the present day. The trend to inclusion of study of new industrial materials like plastics, wood veneers, steel and aluminum alloys, etc. for their individual characteristics, cannot be over-emphasized.

Throughout the text, problem material is in evidence to put into use the principles enumerated and conclusions formed. The book follows a progressive pattern for mental development. The appendix has a resume of information pertinent to the subject considered. Tabular data is also available to assist the student in the solution and study of his problems. This book should meet with ready acceptance within the range for which it was planned to be used.

LUMIR P. BRAZDA
Wilson City College, Chicago

SHOP MATHEMATICS AT WORK, by Paul L. Welton, *Head of Department of Mathematics and Science, Jefferson High School, Rochester, N. Y.;* and William W. Rogers, *Instructor of Related Technical Subjects, Edison High School, Rochester, N. Y.* 1st Edition, pages iv and 204. Numerous illustrations. 21×27 cm. Paper. Spiral Binding. List Price $1.56. Silver Burdett Company, N. Y. 1942.

Under the heading of Shop Mathematics the authors have cut across traditional arithmetic, algebra, geometry, and trigonometry to compile mathematical material common to shop practice. Along with this they have incorporated into the book shop problems for student execution, thus combining text material with problem material into one source of instruction. An examination of the book reveals that this stated purpose in the preface has been met.

A review of the contents indicates that the subject matter has been well selected. The authors' experience within the described field has enabled them to organize instructional material in keeping with sound pedagogic practice. It is believed that with supplementary teaching aid the student should experience little difficulty in making satisfactory progress. Sufficient problem material is available for development of pupil understanding of the respective units of instruction. The illustrations and fundamentals are clearly expressed, thereby relieving the instructor of unnecessary explanation. One is cognizant of the fact that throughout the book the type of student using it has been one of the primary considerations.

LUMIR P. BRAZDA

GENERAL CHEMISTRY FOR COLLEGES, Third Edition, by B. Smith Hopkins, *Professor Emeritus, of Inorganic Chemistry, University of Illinois.* Cloth. Pages 758. 15×23 cm. 1942. D. C. Heath and Company, 285 Columbus Ave., Boston, Mass. Price $3.80.

This popular text book of inorganic chemistry has a sound foundation of organized chemical facts. It has excellent questions and extensive lists of references for outside reading. Chemical arithmetic, after it is introduced, is continuously applied as the descriptive material is presented.

It contains an excellent modern discussion of the Brönsted theory of acids and bases, explains the peculiar properties of water in the terms of the dipole theory, and has a modern solvated ion explanation of hydrolysis. Several helpful diagrams are given including classes of crystals, vapor pressure composition curves for solutions that form maximum and minimum boiling points, and the Vorce chlorine cell.

The text is undoubtedly superior in the presentation of inorganic facts, however one might wish that more of the modern theories and concepts such as ionization potentials, electrode potentials, ionic size, electron

theory in organic chemistry, and the electron theory of oxidation and reduction had been more plentifully used in tying these facts together.

It is an excellent descriptive text with a few very modern theories.

WILLIAM H. MCLAIN
Wilson City College, Chicago

CALCULUS, by Paul L. Evans, *Instructor in Mathematics, Engineering Division, Curtiss-Wright Technical Institute, Glendale, California.* Cloth. Pages vii+126. Ginn and Company. Boston. Price $1.25.

This book is the third in the series "Mathematics For Technical Training" which comprises "Algebra, Plane Trigonometry and Calculus." Since it is necessary to present the course in a limited amount of time, only the most important topics are presented. These are Differentiation, Integration, Maxima and Minima, Derivative as Rate of Change, Differentials, Integration as Summation and some Miscellaneous Applications of Integration to Beams, Centroids and Moments of Integration.

The difficulty with this book is that it is more a handbook with problems than a text. The explanations are cut to a minimum. The formulas are listed without any discussion. Either the instructor will have to supplement the course to the extent of practically writing a new text, or the student will acquire, at best, a routine knowledge of some of the fundamental processes of calculus.

BERNARD FRIEDMAN
Wilson City College
Chicago, Illinois

THE READING OF VERBAL MATERIAL IN NINTH GRADE ALGEBRA, by Margaret Grace McKim, Ph.D. Cloth. Pages viii+133. 23.5×16 cm. 1941. Bureau of Publications, Teachers College, Columbia University, New York. Contributions to Education No. 850. $2.10.

This is a study undertaken to analyze the demands made on the reader by the subject matter of elementary algebra, with criteria for the construction of tests and scoring key, together with two tests reproduced in their entirety. These tests were given under the author's direction in two New York City high schools and the findings tabulated. The findings are significant in determining to what extent the relative efficiency of the reader varies as he changes from one type of reading matter (algebraic or non-algebraic) to another, and in determining the relationship between achievement in reading and achievement in algebra. One conclusion reached by the author is that the teacher who teaches algebra without a text is doing the student an injustice, since the time will eventually come when the ability to read a mathematics textbook will be of primary importance to him, and that the more difficult the textbook, the greater is the tecaher's responsibility in showing him how to read it. The author concludes with a list of problems which merit further study, such as making a similar study in other mathematical branches.

GLENN HEWITT,
Von Steuben High School
Chicago, Illinois

IN HONOR OF A MAN AND AN IDEAL (THREE TALKS ON FREEDOM). Paper. 35 pp. 15.5×21 cm. 1942. Published by Columbia Broadcasting System. New York City.

The "man" is Edward R. Murrow, chief of the European staff of the Columbia Broadcasting System; the ideal, "the freedom of speech and ex-

pression everywhere in the world." The pamphlet consists of three talks on the general subject of freedom of speech over the air, delivered by Archibald MacLeish, Librarian of Congress; William S. Paley, president of CBS and Edward R. Murrow at a dinner given in honor of Mr. Murrow. It is of more interest to teachers of civics than of science or mathematics.

GLENN HEWITT

MICROBIOLOGY AND MAN, by Jorgen Birkeland, *Assistant Professor of Bacteriology, Ohio State University*. Cloth. Pages x+478. 23×16 cm. 1942. F. S. Crofts & Co., New York, N. Y. Price $4.00.

This book is concerned almost entirely with the practical aspects of bacteriology. It was designed by the author as an elementary text for students who plan to take one or two courses in microbiology, and is intended to serve as a basis for an understanding of the part played by microorganisms in every day life. It does not contain many illustrations, but these are well chosen and purposeful.

There are thirty-five chapters in the text. These are grouped into four sections. The first nine chapters are devoted to Fundamentals of Microbiology, the next four to Infection and Resistance, sixteen to Common Infectious Diseases and six to Microbiology of Food, Milk, Water, Sewage and Soils. The book also contains a glossary of terms and an appendix in small print devoted to the classification of the Schizomycetes and a discussion of certain representative types.

The text contains much material that is of practical interest and use to those who plan to specialize in agriculture, medicine and related sciences. However, more material is presented in this text than it seems necessary for an elementary course in bacteriology.

HILMER C. NELSON
Wilson Junior College
Chicago, Illinois

THE SCIENCE OF HEALTH, by Florence L. Meredith, *Professor of Hygiene, Tufts College*. Cloth. Pages xi+427. 23×16 cm. 1942. The Blakiston Company, Philadelphia, Pa. $2.50.

This book is designed for use as a text in one-hour-one-semester college courses in hygiene. The author's objectives are to aid teachers to present hygiene briefly yet in a manner befitting a scientific subject in a college curriculum and to aid students to attain respect for, develop an interest in and profit from such study.

The chapter headings are as follows: 1. Introduction to the Health Situation; 2. The Body in Health and Disease; 3. Supply of Energy; 4. Use of Energy; 5. Renewal of Energy; 6. Thermal Regulation; 7. Cleanliness; 8. Bacterial Injury; 9. Physical Injury; 10. Chemical Injury; 11. Major Disorders of Internal Origin; 12. Brain and Nerves; 13. Mental Health; 14. The Next Generation. An appendix contains the following titles: I. Chemical Composition of Foods; II. 100-calory portions; III. Vitamins; IV. Mortality Statistics; V. Health Organizations; VI. Medical Education and VII. Medical Specialists.

The book is well written and illustrated and should be very useful in an abbreviated course in college hygiene. There is an adequate bibliography added for those who may wish to do additional reading on the subject.

HILMER C. NELSON

SPHERICAL TRIGONOMETRY AND TABLES, by William Anthony Granville, Ph.D., *Formerly President of Gettysburg College*. Revised by Percy F. Smith, Ph.D., *Professor of Mathematics in Yale University*, and James S.

Mikesh, B.A., *Master in Mathematics in Lawrenceville School.* Cloth. Pages viii+270+iv+43. 15×23 cm. 1942. Ginn and Company, Statler Office Building, Park Square, Boston, Mass. Price $1.25.

This text is a revised, separate edition of the Spherical Trigonometry from Granville-Smith's earlier text on Plane and Spherical Trigonometry.

It begins with a recapitulation of the formulas for the plane triangle, and some explanations of geographical coordinates, parallel and plane sailing. Then follows the development of the formulas for the spherical triangle and the solution of the six cases, clearly and concisely presented, with numerical examples worked out completely and in excellent form, and with answers provided for all exercises. Regrettably the haversine formulas are not given, which, in conjunction with a haversine table reduce the numerical work in four of the six cases quite appreciably. Next there are the standard applications to problems of great circle sailing, and finally applications to the celestial sphere.

This latter part is rather meager, which seems unfortunate, in as much as the chief reason for the present revival of interest in spherical trigonometry is its importance for celestial navigation. Neither right ascension nor the Greenwich hour angle are introduced; no mention even is made of the sun's path through the ecliptic, or the distinctions of sidereal and solar time, and of apparent and mean time. Nor do the explanations always seem very happy, as when the reason for treating the celestial sphere as of infinite radius is given as follows:

"We cannot estimate the distance of the surface of this sphere from us further than perceive that it must be very far indeed, because it lies beyond the remotest terrestrial objects. To an observer the stars all seem to be at the same enormous distance from him, since his eyes can judge their directions only and not their distance. We therefore regard this imaginary sphere on which all heavenly bodies seem projected as having a radius of unlimited length." (p. 255)

Why not better speak of the absence of geocentric parallax in the case of the stars? (The proof on p. 258 that the altitude of the pole is equal to the latitude of the observer also strangely omits this point.)

The book contains a four-place table of logarithms, two logarithmic trigonometric tables (one for angles in degrees and minutes, the other for decimal parts of degrees, with conversion tables for angles given in the one form into the other form), and a table of natural trigonometric functions.

Louise Lange
Wilson City College, Chicago

Differential and Integral Calculus, by Harold Maile Bacon, Ph.D., *Assistant Professor of Mathematics, Stanford University.* First Edition. Cloth. 16×24 cm. 1942. McGraw-Hill Book Company, Inc., New York. Pp. viii+772. Price $3.75.

This text is planned to give the student a clear understanding of the basic principles of the calculus as well as a practical working knowledge of the subject. All through the book explanations of sufficient detail appear so as to permit the student to grasp the ideas with a minimum of assistance from the instructor.

The wide and effective use of the calculus is demonstrated in the many geometrical and physical applications that are included in the text. A large number of exercises furnishes the student with the opportunity to test his understanding of the subject.

Joseph J. Urbancek
Chicago Teachers College

DIFFERENTIAL EQUATIONS, by Max Morris, Ph.D., and Orley E. Brown, Ph.D., *Associate Professors of Mathematics, Case School of Applied Science*. Revised Edition. Cloth. 16×24 cm. Prentice-Hall, Inc., New York. 1942. Pp. xii+356. Price $3.00.

Prepared for those students who come to the course with a background of one year of the calculus this textbook serves the purpose well. A searching study of the more theoretical aspects of the subject of Differential Equations is held in abeyance but as the subject is developed numerous opportunities are presented for the development of mathematical rigor. These may be extended at the discretion of the instructor.

Exercises developed in sequence from those that illustrate a definite formula or a specific method lead the student on to something like independent study and criticism. Emphasis has been placed upon sufficient material, adequate definitions, proofs, and discussions that lead to completeness and clearness of thought. Further development of the theory is brought out through the well selected exercises.

JOSEPH J. URBANCEK

A GEOMETRICAL MEANING FOR $f''(x)$

WILLIAM R. RANSOM, *Tufts College, Mass.*

Classes in the Calculus are often puzzled because, while $f'(x)$ has an obvious geometrical meaning, the slope of a tangent to the curve $y=f(x)$, no geometric meaning is given for $f''(x)$, which appears geometrically only in a complicated expression for a radius of curvature.

The vertically symmetric parabola that has the closest contact with the curve $y=f(x)$ at the point where $x=a$ is

$$y=f(a)+f'(a)(x-a)+\tfrac{1}{2}f''(a)(x-a)^2$$

By moving the origin to the vertex of this parabola, its equation takes on the simple form

$$y=\tfrac{1}{2}f''(a)x^2$$

whence

$$y'=xf''(a), \text{ and } y''=f''(a)$$

At the vertex of this parabola, $x=0$, $y'=0$, $y''=f''(a)$, the radius of curvatuve is $R=1\div f''(a)$, and the curvature is $f''(a)$.

Accordingly, $f''(x)$ has this geometric meaning: it is the curvature at its vertex of the vertically symmetric parabola which most closely fits the curve $y=f(x)$ at the point whose abscissa is x.

DISCOVERY OF HEAVY HYDROGEN, WINS FRANKLIN MEDAL FOR DR. HAROLD C. UREY

Discovery of heavy hydrogen, which resulted in opening new vistas in the physical sciences, has won a highly prized Franklin Medal for Dr. Harold Clayton Urey, Columbia University chemist.

Dr. Urey is chiefly known for his discovery of deuterium, or heavy hydrogen, and for the separation and concentration of other isotopes by chemical methods.

Chemists quickly realized the great usefulness of heavy hydrogen in research, and enrichment methods were soon developed. It fathered a wealth of experiments and has been of fundamental importance in the fields of physics, chemistry and biology. Heavy hydrogen is one of the substances used as atom-smasher projectiles to transmute other elements.